The AUTOMATIC ELECTRIC Technical Journal

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April, 1955 Vol. 4, No. 2

THE TYPE 19 SPECIAL SERVICE SWITCHBOARD

By OWEN G. JARBOE

General Traffic Manager, General Telephone Company of California

***SYNOPSIS:** Advantages of consolidating work loads—requirements for a new special service switchboard—The Type 19 Special Service Switchboard.*

WHEN Mark Twain wrote that "one boy is one-half boy and two boys are no boy at all", he was speaking about their ability to get a job done. To a certain degree this might also be said about switchboards since their efficiency decreases with the number of separate ones among which the work is divided. To say it another way, two small separate switchboards are not as efficient, position for position, as one larger one.

To illustrate, assume that we have several classes of calls to handle in an office. The names of these classes, the number of busy hour traffic units and the resulting position requirements taken from the tables of theoretical position requirements might be as follows:

Class	*B. H. Units*	*Positions Required*
Information	540	2.5 (3)
Intercepting	210	1.3 (2)
Dial Assistance	200	1.3 (2)
Toll Rate and Route	125	1.0 (1)
Total	1075	8

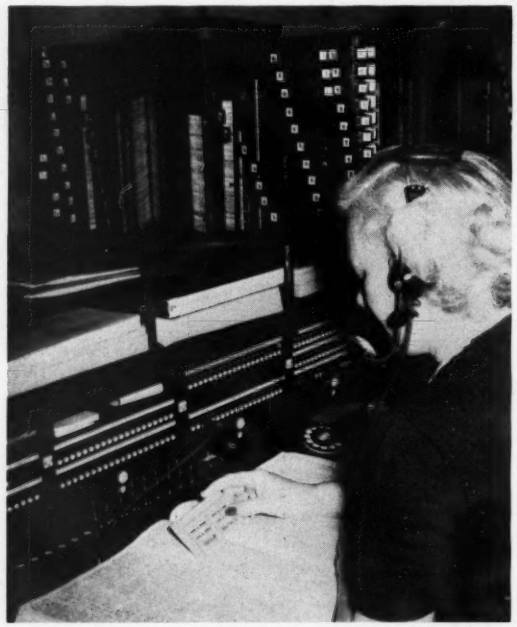
In explanation of the figures enclosed in parentheses above, the rule for the disposition of fractional requirements in positions (or operators) is that where the fraction equals five tenths (0.5) or more, or is greater than the whole number (as 1.2 or 2.3) the fraction is increased to the next highest whole number. It is important to remember this rule because it is on account of it that the considerable savings in expense and investment is made possible through the use of the Automatic Electric Type 19 Special Service Switchboard.

To continue with the foregoing example, if the total of 1075 busy hour units representing the four classes of calls are combined into one group in-

stead of into four, thus being equivalent to one switchboard, 4.7 positions are required instead of the eight shown. By elimination of the fraction, this would require five positions.

As a result, therefore, there is a saving of three switchboard positions and approximately eight operators, the latter being based on the approximate requirement of 2½ operators per position and assuming all positions in use.

It should be recognized that the computation of the number of positions required in the first instance assumes that each class of work is handled on separate switchboards or on separate positions and that the reduced position requirement results from combining all classes of work so that they can be teamed on one switchboard.



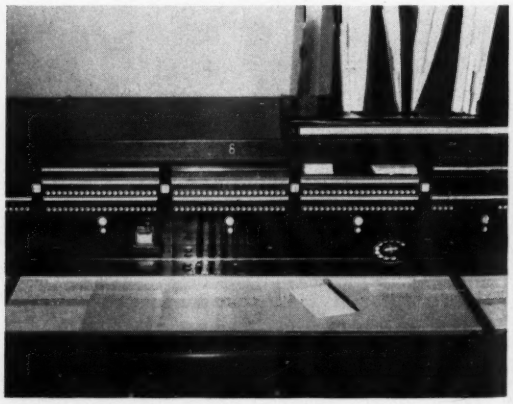
An illustration of how rotary information files and printed information directories may be used together by the addition of directory shelves to the Type 19 Special Service Desk. The place is Whittier, California.

An adaptation of the Type 19 to toll rate, route and ticket sorting work at Oxnard, California.

Requirements for a New Special Service Switchboard

The rapid growth of the General Telephone Company of California beginning soon after the close of World War II brought about large increases in the special service calls to be handled in all of its offices and the existing switchboards were quickly overloaded. Temporary shop-built switchboards were placed in service and other emergency measures were taken to handle the traffic. Then the traffic engineers set about planning permanent switchboards for the handling of special services.

The kinds of services to be handled at the separate locations varied from two to all of those given in the preceding example. Separate positions had in the past been provided for two other types of



A close-up view of the key shelf and face equipment of the Type 19 Desk. This one is at Santa Monica, California. A special feature at this office (not shown) is the multipling of the turret equipment from the separate Type 6 Special Service Desk on the key shelf of the Type 19 for night use (See the Automatic Electric Technical Journal, March 1954).

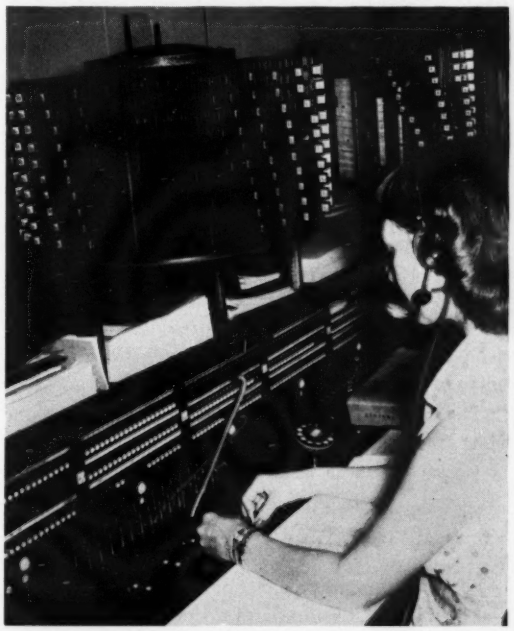
traffic which, if they could be combined and teamed on one switchboard would improve the efficiency and reduce the cost as well as provide better service. These were: Company PBX and Toll Rate and Route — in toll offices. An added complication was the necessity of being able to give information from both printed directories and rotary information files.

It was decided that a cord-type board having six pairs of cords would be necessary. Also, due to the need for reference to rotary information files, it had to have a low turret. Furthermore, it had to have a key shelf wide enough for printed information directories and intercepting records. From calling rate figures and probability tables, it was determined that about forty-five strips of twenty-per-strip jacks provide enough face equipment on a five-panel basis to handle all the services that would ever be required. This resulted in a face equipment opening per panel of nine strips or 4½ inches.

Thus, the physical aspect of the proposed switchboard took shape. It was small and compact, yet it was adequate for the purpose. The only limiting factor was that the single tier rotary information files could accommodate not more than 70,000 listings.

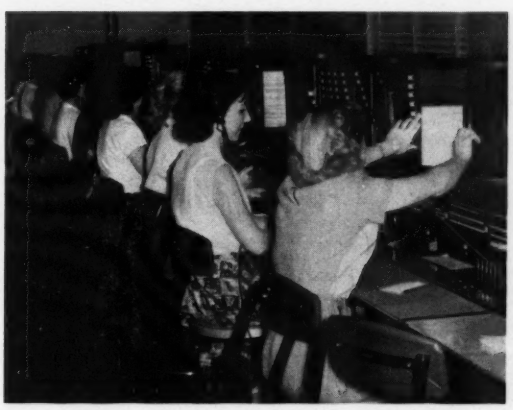
Another class of work handled either at separate positions of the toll switchboard or at a special desk was toll rate, route and ticket sorting work. By installing a ticket sorting table and rack at right angles to an end position of the switchboard, this work could be transferred from an expensive toll position or a special desk at toll offices.

It was further found that by increasing the cord pairs to fourteen on a position, and to eight on the

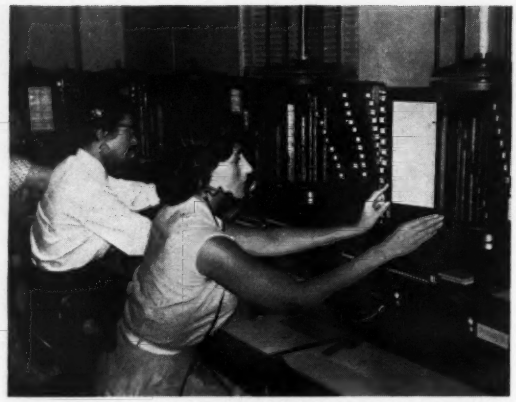


An operator at Whittier, California handles Company PBX calls. Information files and intercepting records are available for her use when teaming with these services.

Whittier, California is within the extended area of Los Angeles; therefore it was necessary to provide shelves for holding the five volumes of the printed directory comprising the entire area. Rotary information files contain local listings. In addition to Information, Intercepting, Dial Assistance and Company PBX are handled on the Type 19 switchboard.



San Bernardino, California has 12 positions of Type 19 Desk. Information, Intercepting and Dial Assistance are handled here.



The Type 19 in use at Santa Barbara. Type of special services handled here are Information, Intercepting, Dial Assistance and Company PBX (not shown).

adjacent position, upward to sixty PBX lines could be handled, thus doing away with a separate Company PBX switchboard which previously had either been assigned to an expensive operating position or to a standard PBX attendant's cabinet which had intruded itself into the operating room floor plan and was covered by an operator, a large part of whose time was wasted.

The Type 19 Special Service Switchboard

From the foregoing concept was evolved the Special Service desk manufactured by Automatic Electric Company and designated the Type 19. The earliest installed by the General Telephone Company of California was at Pomona, California in 1948. Since then the Type 19 has been installed at eight other offices and the tenth will be cut over at Lancaster, California, in 1955. Some handle only two services, for example, information and intercepting, while on others assistance traffic is handled and in addition, Company PBX and toll rate and route. They range in size from five to seventeen positions.

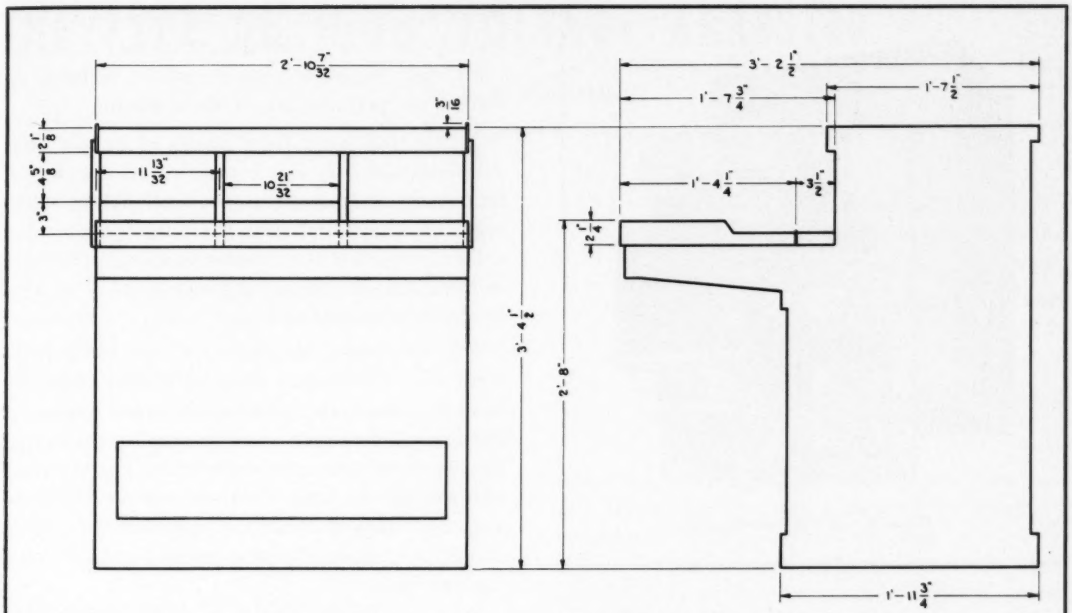
The expanding use made of the Type 19 is in itself testimony to its efficiency. Chief among its desirable points is the economy of operation which, as previously pointed out, results from the teaming of different types of work on one switchboard. No longer is there a disparity in the grade of service furnished on different types of special service calls since all are accessible to a larger team of operators which makes for better service by providing a more uniform answering time.

A still further advantage gained by combining various types of work on one switchboard results from a better working placement of lines of switchboard, thereby reducing supervision and making it more effective. This has also resulted in floor space economy and avoids expensive rearrangement of switchboard equipment in cases of rapid growth. Not to be ignored in this day of constantly increasing requirements for DSA board and toll board positions is the need for transferring from them all work that it is possible to do on the far less expensive Special Service switchboard.

That better employee efficiency, meaning increased employee-hour loads, results from this combination of forces goes without saying. Experience has indicated that this may be as high as 40%.

The possibilities of the entire team of operators being able to absorb an unusual peak of any one of the classes of traffic handled is an advantage that is included in the larger spread of board but which might be overlooked. For example, a convention, or homecoming day at a college, or movement of the armed forces may cause a peak on information that a separate information switchboard would be hard pressed to handle. Or there may be at another time a rush on intercepting service caused by a group of temporary disconnects. It is improbable that the same peak would occur simul-

The Company PBX is operated from an end position of the Type 19 Desk at Oxnard, California. It can be teamed with Information or Intercepting — or the adjacent position can assist the PBX operator if necessary.



Front and end design and dimensions of the Type 19 Special Service Switchboard.

taneously on the other special services and that the flexibility of this switchboard arrangement will permit more operators to concentrate on the type of service that is the busiest.

Other types of services not previously mentioned which can be combined on the Type 19 switchboard are repair service, verification service and more recently, automatic toll ticketing calls requiring operator assistance. In every respect this switchboard has earned the name, the "Workhorse of Special Service Boards."

THE POWERINGER

The magnetic cross valve, invented by H. J. McCreary of Automatic Electric Company, Chicago, consists of an iron core, square-shaped on the outside and made of E-shaped and I-shaped laminations. Two coils are wound on this core so that their axes are at right angles as shown in Figure 1.

With the input coil *A* energized, no voltage will be generated in the output coil *B* as the mutual inductance between the coils is zero. However, if a suitable condenser is connected across the output coil, and a transient voltage is introduced into the coil, oscillations will start up in the output coil and will remain as long as the input coil is energized.

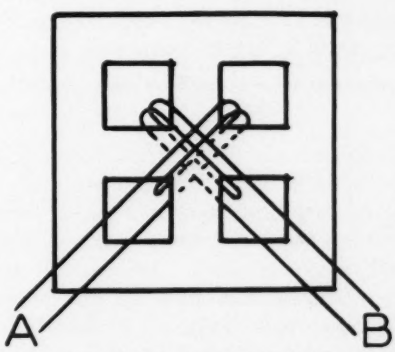


Figure 1. Basic Construction of Magnetic Cross Valve.

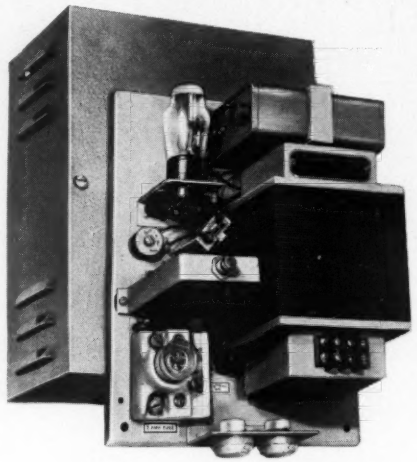


Figure 2. 60 - 20 PoweRinger.

If the current in the output coil is sufficient to cause a degree of saturation, then an "odd" subharmonic of the voltage in the input coil may be generated in the output coil. An "even" subharmonic may be obtained by superimposing a continuous DC voltage on the input coil.

It is immediately apparent that the cross-valve could be the basis of a ringing converter which would be entirely static—free from all moving parts.

Figure 2 shows such a converter made by Automatic Electric (Canada) 1953 Limited, Brockville, Ontario. This unit is called a "PoweRinger" and it converts a 60-cycle, 115-volt input to 20-cycle, 85-volt output. Similar units have been designed and field tested for 50- to 25-cycle, 60- to 30-cycle and 50- to 16-2/3-cycle conversion.

An electron tube is used to start oscillations in the secondary circuit. Once oscillations have been set up, the tube is biased out. In fact it can be completely removed from its socket without affecting the performance of the converter.

The output wave form produced by the cross valve contains very few harmonics. As the ringing frequencies themselves are not audible, harmonics must be introduced into the output to tell the calling party that the called subscriber's telephone is being called. This "ringback tone" is created by the use of a tone coil.

The cross-valve converter will operate satisfactorily over a frequency range of several cycles per second around the designated input frequency. However, if the input frequency varies, the output frequency will vary proportionately. The efficiency varies with the load. At rated output (25 volt-amperes) the efficiency is approximately 45%, which is considered quite good for such small equipment.

The units are not seriously affected by input voltage variations of 10-15% from the rated value. If the input falls considerably below the rated value oscillations will stop, but as soon as the voltage builds up again the tube will "fire" and oscillations will restart.

Experimental models of the PoweRinger have been in service for several years without requiring maintenance of any kind. Commercially produced models have been in the field in Canada for about four years and they have been very well received.

In addition to supplying the telephone ringing power, PoweRingers can be used in railway signaling systems, fire alarms, broadcasting stations and in any other application where a reliable, noiseless, stable frequency converter is required to provide low-frequency power.

R. C. Tivy, *Brockville*

THE TYPE 56 HIGH VOLTAGE ARRESTER

By E. C. COULOMBE

Departmental Engineering Supervisor, Automatic Electric Company

SYNOPSIS: Problems of joint pole construction — limitations of substation protectors—The Type 56 High Voltage Arrester — design requirements — operation.

THERE was a time when both power and telephone line systems were generally open wire and kept widely spaced except at crossings. As these systems expanded it became increasingly difficult to maintain this separation, and as a result there are vast areas where over-builds and joint pole construction are in operation.

During the early years of joint pole use, the power circuit operating voltages were usually limited to 5 kv. More recently, however, the tendency has been to use higher voltages, so that at present the power circuit arrangement may involve potentials as high as 14.4 kv to neutral.

Problems of Joint Pole Construction

Of course, possible contacts between power and telephone lines are not peculiar to joint use. On account of the number of crossings and conflicts in some locations, the use of separate pole lines may not change the exposure sufficiently to provide a satisfactory solution. Thus, on joint poles or on separate poles, where telephone lines are in close proximity to power circuits and subject to power crosses, protection devices should be provided that can be relied upon to keep personnel injuries and fire losses at a minimum.

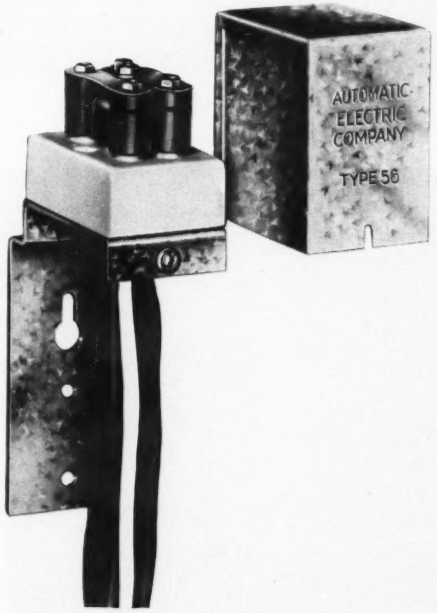


Figure 1. The Type 56 High Voltage Arrester.

Limitation of Substation Protectors

Most telephone subscribers' stations that are subject to exposures are now protected with substation protectors consisting of discharge blocks and fuses. In other words, each line conductor has a fuse in series with a spark gap to ground. The fuses are on the line side of the blocks so that when the gaps operate, the fuses are ruptured and clear the subscriber and his instrument from dangerous fault currents. This arrangement has proved quite satisfactory, but since the standard 4″ fuse can be relied upon to interrupt potentials up to about 4 kv only, other means must be employed to deal with voltage of the magnitude encountered in much of the present joint pole construction.

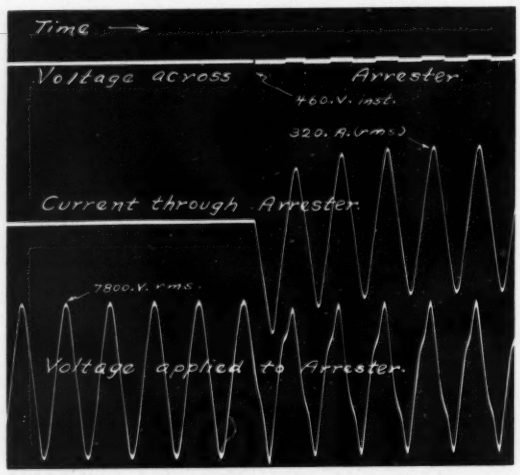
There is no such thing as absolute safety, because there are unseen hazards in all situations. However, failure to employ dependable protective devices is courting trouble, since life and property may be endangered. Thus, telephone lines in danger of contact with electric power supply circuits should be equipped with pole arresters capable of drawing off high voltage power currents before they reach the subscriber's premises.

Telephone operating companies have made numerous requests for an arrester capable of saving their lines from danger when crossed with R.E.A. or other power circuits. As a result of the above hazards, the Type 56 High Voltage Arrester was developed.

Design Requirements

In undertaking this project it was recognized that such an arrester should be a highly reliable device and capable of limiting the magnitude of fault currents on telephone lines. Also, because the extent of the damage to a telephone plant is often proportional to the duration of the contact, such an arrester should function promptly to de-energize the power circuit when conflicts occur. By providing a ground for the power line, the power substation circuit breaker is made to function and to open the power circuit. In addition, it should not cause unnecessary service interruptions and should

Figures 2-9. Oscillograms showing operating characteristics of the Type 56 High Voltage Arrester under test conditions.



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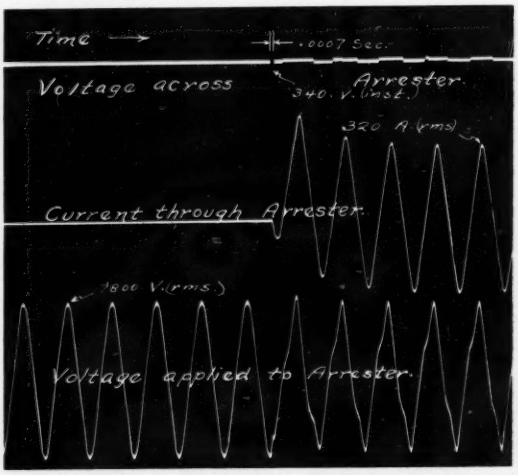

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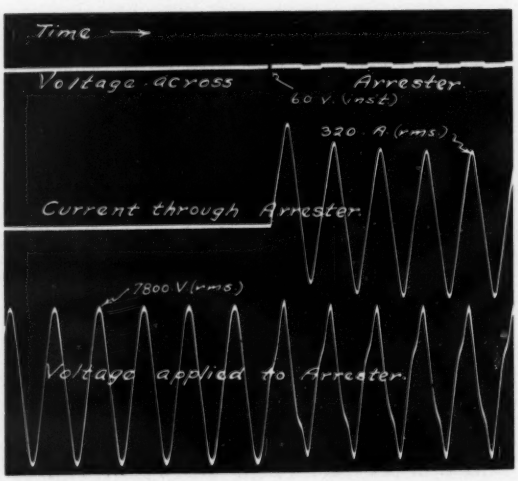

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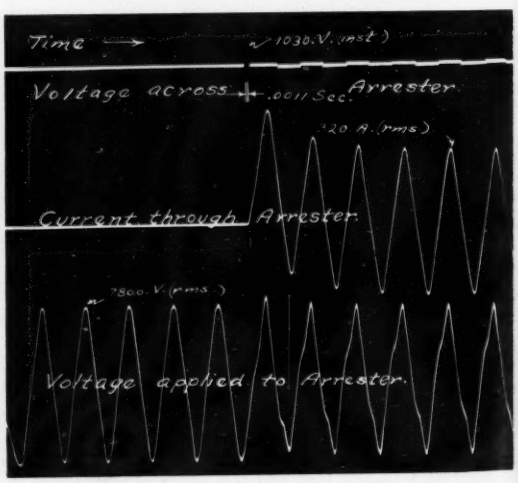


Figure 5.

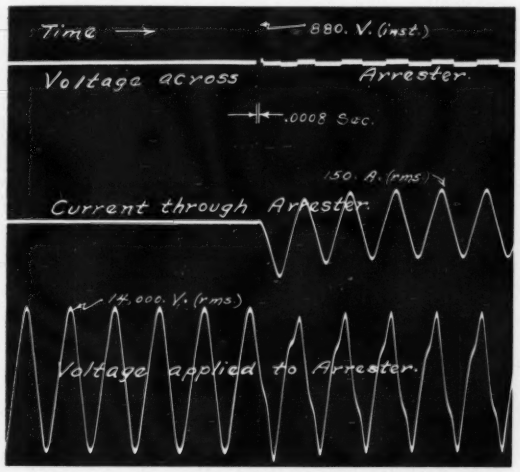
be designed so that it can be manufactured at reasonable cost.

The American Standards Association defines a lightning arrester as a device which has the property of reducing the voltage of a surge applied to its terminals, is capable of interrupting follow current, if present, and restoring itself to its original operating conditions. While in the past this definition has been limited to power plants, safety requires that the same requirements should also be applied to communication lines where such lines are on the same poles with high voltage power wires.

Operation

The Type 56 Arrester has been developed in accordance with these requirements. This arrester operates on the arc gap and thermostatic principle and automatically switches heavy fault currents to ground and resets itself when the power circuit has been de-energized, or when for any reason the fault current on the telephone line ceases to exist.

The Type 56 Arrester includes the mounting bracket and cover, a glazed porcelain base, four line electrodes, one ground electrode, and a bimetallic grounding plate with four contactors (See



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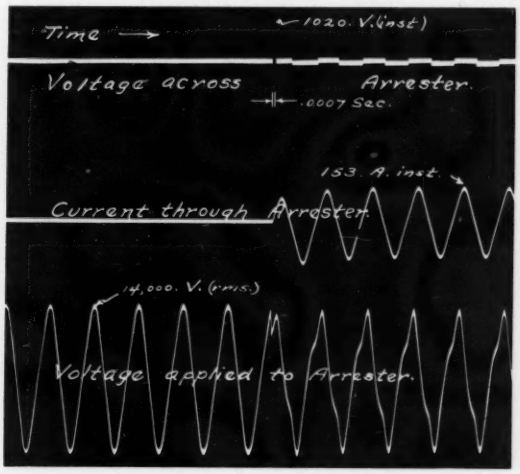
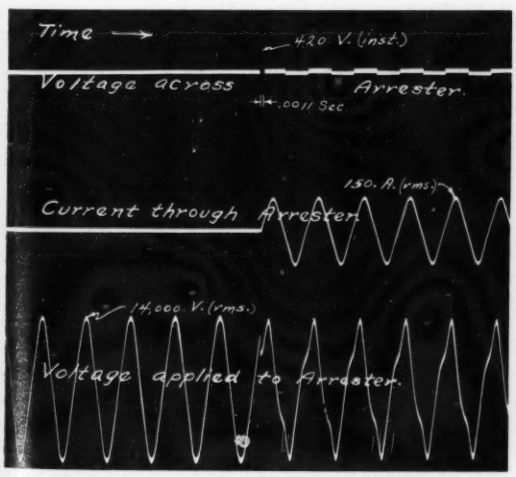


Figure 8.



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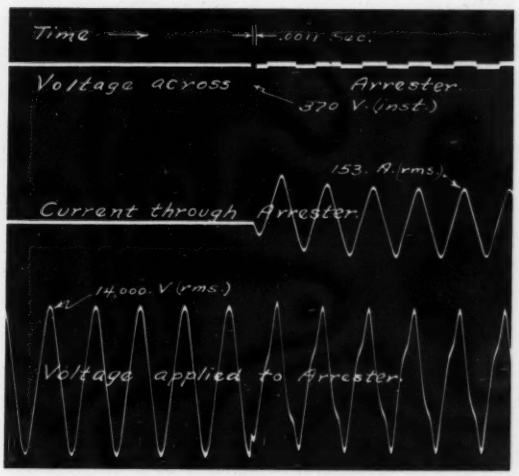


Figure 9.

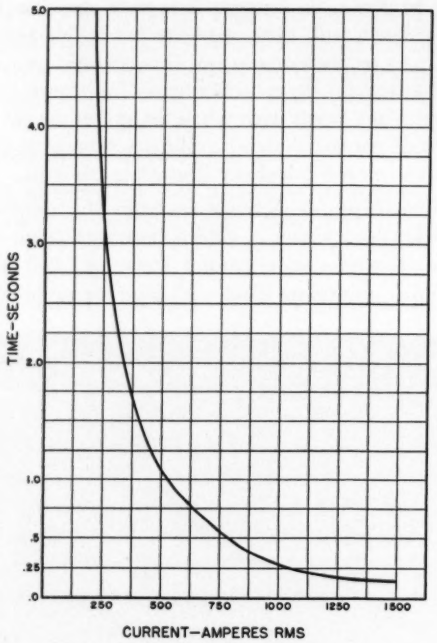


Figure 10. Current-carrying ability of Type 56 High Voltage Arrester. Each point on the curve represents 3 applications of current for the given length of time.

Figure 1). Each of the contactors mates with a line electrode so that when the bi-metal plate bends, the contactors will engage their line electrodes and connect them with ground. (See Figure 11).

When a power system voltage impressed on a telephone plant exceeds the capacity of the telephone fuse an arc may be established across the fuse. Such an arc, in most cases, will result in damage. On the other hand, if the fuse functions to open the circuit, the high potential will remain on the drop wire. If such potential is above the dielectric strength of these conductors there may be insulation failure that will result in damage.

The Type 56 Arrester serves to keep power circuit potentials well within the interrupting ability of the telephone station protector. It also switches heavy fault currents to ground and automatically resets itself after such currents have been removed from the telephone plant.

In this arrester there are two separate paths between the line and ground electrodes. One path is through the arc which may exist between these parts, the other path is by way of the short circuit, which results when the bi-metal bends to connect the contactors with the line electrodes. This may be best understood by reference to the oscillograms (Figures 2 to 9) which show that when a surge of power current establishes an arc between a line electrode and the ground electrode, such condition persists for only a few milliseconds because the extreme heat from the arc causes the bi-metal to bend and to ground the telephone line. After grounding has taken place, no number of reclosures by the power-controlling mechanism will re-establish an arc at the arrester, or again raise the voltage on the subscriber's drop leads until the bi-metal has cooled and reset itself. This resetting time will vary from a few seconds to a few minutes, depending upon the duration and intensity of the cross and upon ambient conditions.

The oscillograms show the remarkable operation of this arrester. The lower sine wave represents the applied voltage. The center trace represents the current through the arrester, and is zero before the cross. The upper trace represents the voltage across the arrester, and is also zero before the cross. It rises to an instantaneous maximum during the operation of the arrester and then drops to a very low value, less than 50 volts. Three important features of the arrester are vividly described by the series of oscillograms:

1. Fast operate time—The maximum operate time for any test was 0.0035 second and the minimum was not measurable (less than 0.0005 second).

2. Positive protection—In all cases the voltage across the arrester after operation was less than 50 volts. Test voltages applied varied from 3000 to 22,000 volts (RMS).

3. Durability—Four tests (See Figures 2, 3, 4, and 5) were made on the same line electrode. Only a very slight change was noticeable in the operate time (less than 0.0005 second with the first voltage application, and 0.0011 second on the fourth application) and no measurable increase in residual voltage. No damage could be observed in the arrester from these tests. These four tests were made at 7800 volts and 320 amperes. The tests shown in Figures 6, 7, 8, and 9 were run at

14,000 volts and 150 amperes. Comparable results were observed.

Figures 2 to 9 reveal the operation of this arrester under repeated applications of power for only a few cycles duration.

The curve of Figure 10 shows the current-time characteristics of the arrester. The method by which the data for the curve were acquired must be thoroughly understood before it can be correctly interpreted. Each point was found by applying the indicated current for the corresponding time, three times in succession, to the same airgap.

In these tests the heat developed, rather than the initial arc, was the damaging factor. After each application of current the arrester was allowed to cool sufficiently to release the bi-metal and clear the line. In all cases the bi-metal cleared and the arrester would offer the same protection to a fourth application of power as it did initially.

We know, therefore, that an arrester subjected to current as shown is still capable of giving protection for at least one more application. It may be capable of withstanding many more applications; but inasmuch as most power line circuit breakers reclose twice before permanent opening, three applications were applied in the tests.

The extreme heat developed causes a deterioration of the current-carrying metal parts. However, through the use of the bi-metal the arc is quickly extinguished, protecting the gap and thereby maintaining the protective characteristics of the arrester.

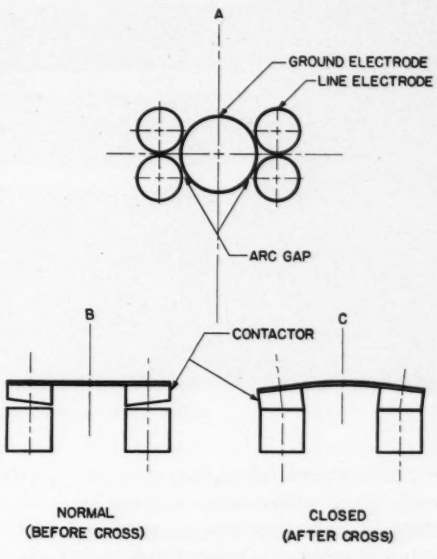


Figure 11. Outline drawing of Type 56 High Voltage Arrester's operating elements.

The Type 56 Arrester does not replace the sub-station protector. It is added protection to safeguard against potentials that are too high to be interrupted by the sub-station protector. There is also no fixed rule to govern the number of pole arresters that should be installed in any location, but experience suggests that they be placed at the end of each circuit and at regular intervals of one-half mile apart throughout the exposure range.

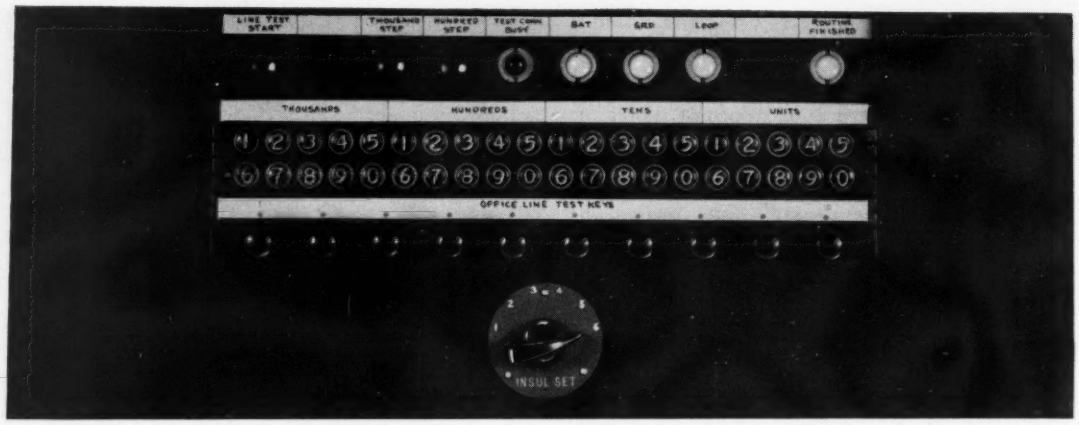
AUTOMATIC ROUTINER FOR LINE INSULATION TESTING

The Automatic Routiner for Line Insulation Testing can enable operating companies virtually to eliminate insulation failure as a cause of trouble in the outside plant.

Progressive operating companies have long realized the advantages of routine testing to detect faults in the plant before they have reached the point where they interfere with service. Up until recently, it has been difficult or impossible to apply this technique in that area where it promises to be most fruitful—the outside plant.

Apart from outright failures due to mechanical damage to the conductors, which cannot be anticipated, the most usual cause of cable troubles is the entrance of moisture through breaks in the sheath. Usually, the moisture signals its presence in the form of reduced insulation resistance long before the resistance has fallen enough to interfere with service. The problem is to recognize this warning of incipient failure early enough so that the sheath can be repaired before trouble results.

Some companies have made a practice of rou-



Control Panel for the Automatic Routiner for Line Insulation Testing.

tining their outside plant manually (using a meter to make the standard tests), but the job is so time-consuming, expensive and monotonous that it is usually not repeated frequently enough to be very effective. Too, the best time to make the tests is in the early morning hours when the contraction of the air in the cooling cable has drawn in damp outside air, but testmen are not usually available for this duty at this time.

The Automatic Line Routiner changes this completely. It operates so rapidly (30 lines per minute) that an entire 5000-terminal office unit can be routined in three hours or less. A testman would need 40 to 75 hours for the same job. The testman's attention is required only for starting, and for occasional restarting when a faulty line is found. Thus, he is free to devote practically his entire attention to other duties about the office.

The Routiner makes the three tests that are standard for this type of routine—leak from either conductor to ground, leak between the conductors, and leak to another pair. These tests, of course, will detect not only wet cables but any other type of fault that results in a leak (faulty drops, or broken insulators on open wire, for instance). The test sensitivity is adjustable over a wide range to meet local requirements.

Access to the lines to be tested is obtained through the regular test switch train. Assuming that the test train is available, no extra equipment is needed other than the Routiner itself. Installation is very simple, and the cost of the equipment is so low that it can be justified in practically all offices of 1000 lines or more, and sometimes even in smaller offices, as in wet climates, where insulation failures are particularly troublesome.

The Routiner is largely self-supervising, so that any trouble it finds *within itself* is also brought to the attention of the testman. The simplicity of the circuit and ruggedness of the apparatus makes trouble unlikely, but the automatic supervision is valuable assurance that faulty lines are not being passed over.

If the Routiner encounters a busy line, it merely passes it over without testing. To wait for a busy line to become free would delay the testing unduly. Because the testing is carried on in periods of low traffic, relatively few lines are skipped. There is practically no chance that any one line will be skipped in each of two or three successive routines.

Because the Routiner uses the regular test train, it is possible that a test connector will be found busy. If so, the Routiner stops and waits for the connector to become idle, after which the connector is seized and testing proceeds. The waiting condition is indicated by a signal, and the testman can by-pass the busy connector by pressing the start button.

The control elements of the Routiner are concentrated in a panel which can be mounted either in the jack field of the test desk, in a turret atop the desk, or on a relay rack in the switchroom. Lamps on the panel indicate which line is being tested at any moment. Other lamps light when a fault is

found to indicate the type of fault—loop, ground, or battery (leak to another pair). Two other lamps indicate "test connector busy" and "routine finished".

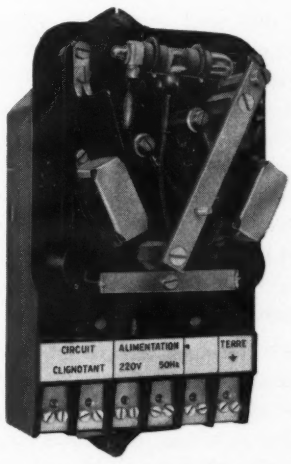
A tap switch on the panel is used to select the degree of sensitivity. If more than one office unit is to be tested, keys are provided by means of which the particular office unit to be tested may be selected. A pushkey is used to start the unit, and restart it as required. Two pushkeys are used to preselect the hundreds group in which testing is to start, in case only a portion of the office is to be tested.

The Routiner apparatus is mounted on relay racks in the switchroom. A choice of mounting is available for racks either 19½ inches or 28⅜ inches wide. The apparatus requires about 19 inches of space on the narrow racks, and about 12 inches on the wide one.

R. J. MAGUIRE, *Chicago*

HIGHWAY SIGNAL FLASHER

A new addition to the range of highway signal equipment manufactured by Automatique Electrique, S.A., Antwerp, Belgium, is a signal flasher which is noteworthy for simplicity and compactness of design. The flasher operates on 50/60 cycles, 110 or 220 volts, and can be used to interrupt lamp circuits aggregating a non-inductive load up to 8 amperes. One flasher can, therefore, control all the warning signals normally required at any intersection. The flashing frequency is 60 p.m. for 50 cycle supply or 72 p.m. for 60 cycle supply. Means are provided for using external resistances where it is desired to prolong the life of a lamp by maintaining a partial current in the lamp circut instead of a complete break at each interruption. The facility for varying the opening and closing of the lamp circuit to give a long light and short dark period or short light and long dark period, is a screw adjustment. The same screw permits the leveling of the mercury contact in cases where the flasher is not mounted quite vertically. A tumbler type switch is fitted to allow the cutting in or out of the entire flasher installation. Normally, the flasher unit is mounted on a separate plate which also carries the installation fuses, and the whole can usually be fitted in the opening provided in the base of the lamp standard for the cable connections. Full protection against radio interference is provided by a highly efficient suppressor system.



Highway Signal Flasher.

V. ANTHONIS, *Antwerp*

A TRAFFIC GRADING OVERFLOW LINEFINDER UNIT

By COLEMAN T. KEELEY

Engineer, Equipment Planning, Automatic Electric Company

SYNOPSIS: *Description — general operation — specific example and circuit description — mounting arrangement — cabling — application — summary.*

COINCIDENT with the rapid growth of subscriber lines during the last decade, there has been a gradual rise in the amount of traffic originated per line in automatic telephone exchanges. As a result of this trend toward increased traffic per line, 200-line groups in some of the older exchanges now offer traffic which requires linefinder switches in excess of the capacity of the existing linefinder shelves. This condition has imposed upon affected operating companies the problem of maintaining a satisfactory grade of service to subscribers assigned to overloaded linefinder groups.

In offices equipped with linefinder shelves that are arranged for "overflow", traffic relief can normally be provided by the installation of overflow shelves. (A conventional overflow shelf is a shelf frame, mounting nothing but linefinders and banks, which increases the linefinder capacity of its associated regular linefinder shelf). Occasionally, however, it develops that although an office is so equipped, space is not available to accommodate one conventional overflow shelf for each overloaded regular shelf and consequently the office can be provided with only partial relief.

If an office is equipped with linefinder shelves that are not arranged for overflow, a traffic overload condition in a 200-line group can be relieved only by reducing the number of working lines in the affected group to a point where the available linefinders can carry the traffic.

In the past this reduction of traffic has been accomplished by either not assigning new subscribers to lines on which the service had been discontinued, or by re-assigning working lines to a new linefinder group. If Line I.D.F. facilities are not available, the transfer of lines from one group to another requires corresponding changes in subscribers' directory numbers. Even when these facilities are present, traffic relief by re-assignment of working lines usually involves loss of the use of a number of line equipments and/or otherwise usable mounting space and wiring for working line equipments.

It can be readily seen, from the conditions that may arise in an overloaded office, that a definite need exists for a means of traffic relief that requires relatively little space in the office and that can provide service to linefinder shelves that are not arranged for overflow.

To meet this need, Automatic Electric Company has developed the Traffic-Grading Overflow Linefinder Unit, which provides practical, efficient and economical traffic relief to overloaded 200-line linefinder shelves. The mounting requirements and circuit characteristics of this unit are such that it can readily be applied in offices where, for various reasons, conventional means of traffic relief cannot be accommodated.

General Features

This unit is arranged to provide traffic-grading overflow service to 200 lines associated with a maximum of 10 regular 200-line finder shelves. It provides relief to several overloaded regular linefinder shelves by serving a portion of the originating traffic of each shelf.[1] Thus the unit permits the traffic of the regular linefinder shelves to be reduced to a point where it can be adequately handled by their linefinders. The transfer of traffic

[1] The idea of using one "overflow" unit to offer traffic relief to a number of overloaded linefinder shelves was advanced by E. L. Swartz, Chief Operating Engineer of Automatic Electric Company, and has served as the basis for the design of this unit (U. S. Pat. 2690479).

from the regular shelves to the relief unit is accomplished by cabling a certain amount of line equipments from the regular shelf to the banks of the overflow unit, where they have access to a maximum of twenty linefinders.

The number of lines from any one regular shelf that will be served by the linefinders of the overflow unit is, of course, dependent upon the extent of the overload condition in the respective 200-line group. Moreover, the lines to be served must be selected in groups of 20 lines associated with the same start circuit and linefinder bank levels. These groups can be assigned to any 20-line-terminal group associated with one start lead in the overflow unit.

The regular line equipments remain on the regular shelves, and therefore, are fully utilized with no loss of space or wiring. The lines selected for overflow service remain associated with the regular line groups and consequently no change in subscribers' numbering is necessary, even when no Line I.D.F. is provided.

Physical Description

Basically the new linefinder shelf is a 20 switch shelf, complete with *A* & *B* group relays and distributors, *but without line equipments.* The ten start leads, which normally run from the start and level-marking resistors to the line relay groups on regular linefinder shelves, are brought out to a terminal block via the spring combination on one of five transfer relays. These transfer relays are controlled by a transfer control relay which is multipled with the shelf A.T.B. (All-Trunks-Busy) meter lead.

The 200 line terminals of this unit are divided into groups *A* & *B* in the conventional manner, and terminate on 600-point bank terminal blocks. The unit provides all features normally found on a 200-line linefinder shelf and is arranged for A.T.B. and peg count metering.

Since connections to the overflow unit are made by machine-made cable, through terminal blocks, the unit need not be mounted adjacent to the regular shelves but can be located anywhere in the office where sufficient vacant space exists.

General Operation

The line relay groups that are selected for overflow service are multipled from the regular shelves to assigned line-terminal groups on the overflow unit. The start leads of these line relay groups are looped through "break-make" spring combinations of the transfer relays on the overflow unit so that the start leads are normally extended only to the vertical bank contacts on the overflow unit. Consequently, when a line in an overflow group makes a call, the assigned level will normally be marked and the line hunted in the overflow unit only. But if an "all-trunks-busy" condition occurs on the overflow unit, the transfer relays will connect the start leads back to the regular linefinder shelves. Only then will these line relay groups be served by the regular shelves.

It should be understood that the lines served by the relief unit remain cabled to linefinder banks of the regular shelves. Hence when the start leads are transferred, calls from the overflow lines can be readily handled by the regular linefinders.

If the line circuits transferred to the relief unit are properly selected, the load of these units can be controlled to avoid A.T.B. conditions. However, if such a condition should occur, the chance of simultaneous peak loads in the regular shelves is very small; hence the temporary transfer of the various line groups back to their "parent" shelves is almost certain to provide service for any line attempting to call while the relief unit is carrying its full load.

Circuit Description of Special Application

Figure 1 shows schematically how the overflow unit provides traffic relief to a 200-line linefinder shelf. In this example, the unit serves 40 lines associated with one regular shelf; however it should be remembered that the 200 line terminals of this unit can serve 160 additional lines—for example, 40 subscribers' line relays from each of four other regular shelves, or 20 lines from each of 8 other groups. It should also be understood that the relief shelf need not necessarily serve 200 lines. Its traffic capacity (20 linefinders) determines how many lines it can serve to give adequate service.

The two 20-line groups selected for overflow

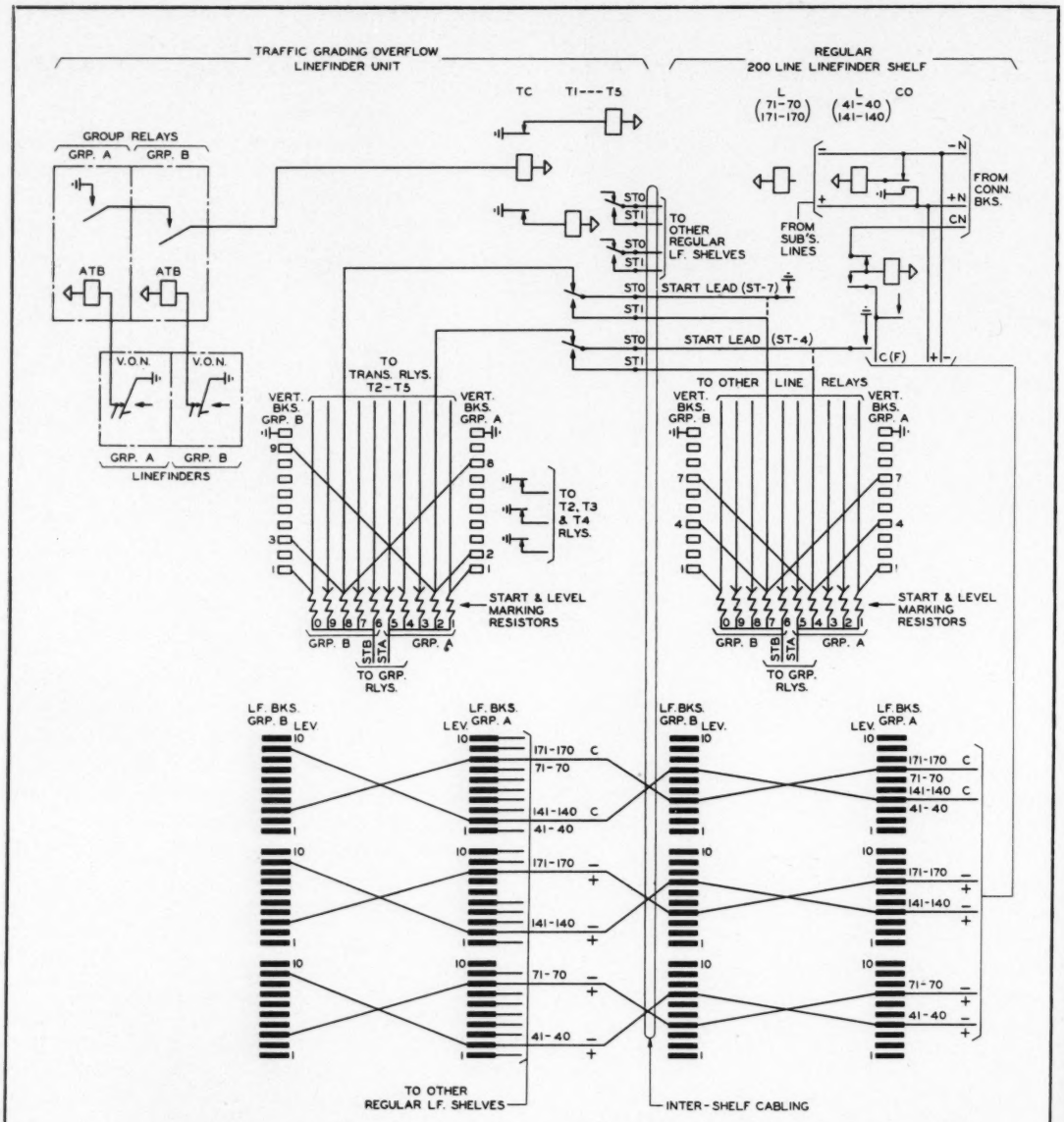


Figure 1. Schematic diagram of overflow unit serving forty lines associated with one regular shelf.

service on the regular shelf are groups 41-40, 141-140 & 71-70, 171-170. In the figure, lines 41-40 & 141-140 have been assigned to line terminals 21-20 & 121-120, respectively, on the overflow unit, and lines 71-70 & 171-170 have been assigned to line terminals 81-80 & 181-180.

The +, — and *C* leads of these lines are multiplied to the assigned +, — and *C* line terminals on the banks of the relief unit linefinders. The two start circuits of these lines, which normally terminate on their associated vertical bank contacts (shown by dotted lines—see Fig. 1), are looped thru the spring combination of the transfer relay *T1* on the overflow unit. This

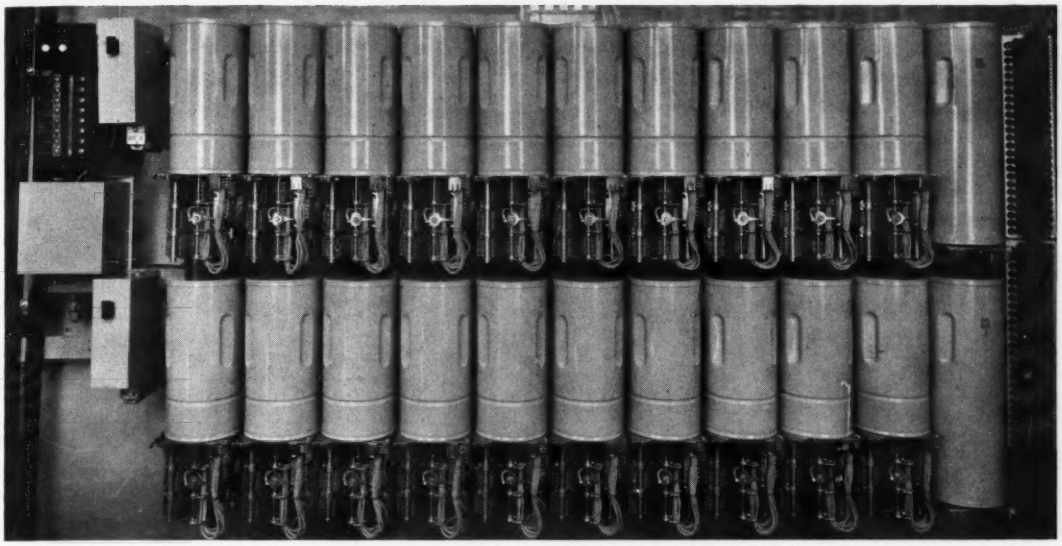


Figure 2. Typical Traffic grading Overflow Linefinder unit.

relay is normally held operated by ground from the transfer control relay *TC*. The *T1* relay, being operated, opens the start leads *ST-4* and *ST-7*, and transfers them to the vertical banks of the overflow unit.

With the circuit in this condition, assume that a call is initiated by a line in the 41-40 overflow line group. Operation of the associated line relay *L* will place ground on the group start lead, *ST-4*. Since the start lead has been transferred to the overflow unit, vertical bank contacts 2 of Group A and 9 of Group B will be marked by ground. With the levels of the calling line so marked, a linefinder in the overflow unit will operate to find the calling line and extend it to the first selector. (Since the method by which this unit finds the calling line and extends it to a selector is the same as that employed by regular 200-line linefinder circuits, a detailed description of these operations is not presented.)

Under normal conditions, the bank levels of the overflow lines will be marked, and the lines "found", in the overflow unit only. The regular shelf linefinders will normally not hunt over the levels 4 and 7 but only over the 8 levels associated with the remaining 160 lines.

If all linefinders on the relief unit should be busy, an A.T.B. condition occurs in both the *A* & *B* linefinder groups of the overflow unit. The lines wired to the overflow unit are then transferred back to the regular shelf because holding ground for the A.T.B. relays in the group relay equipments is removed at the V.O.N. (Vertical-Off-Normal) springs of the line finders. Release of these relays completes the circuit to the *TC* relay, which operates and opens the holding circuit for the *T* relays. The *T1* relay now releases and transfers start leads *ST-4* and *ST-7* back to the vertical banks of the regular shelf. With their start circuits extended back to the regular shelf, these lines can now be served by the regular shelf, but only as long as the A.T.B. condition exists. When the A.T.B. condition has cleared, the *T1* relay will reoperate and transfer the *ST-4* and *ST-7* leads back to the overflow unit so the overflow line group traffic will again be handled by the overflow unit.

Table A shows the line terminals and start circuits of the overflow unit divided into ten groups of twenty lines and one start circuit each. Table B shows the regular shelf line groups recommended for overflow use. Note that lines which appear in bank levels 1, 5, 6 and 10 of either the group *A* or group *B* linefinders are not shown and should not be considered for overflow service. We may

say that the use of these lines is avoided because the regular shelf finders are arranged to automatically cut-in and search on the 5th and 10th bank levels if a vertical marking is not found while searching over levels 1 to 4 and 6 to 9. By limiting transfer to the lines shown in Table B this special circuit feature is not involved in the transfer circuit.

Table A

The 20-line terminal groups and associated start circuits of the overflow unit that are available for overflow service.

Line Terminals	*Start Lead Circuits*
11-10, 111-110	1
21-20, 121-120	2
31-30, 131-130	3
41-40, 141-140	4
51-50, 151-150	5
61-60, 161-160	6
71-70, 171-170	7
81-80, 181-180	8
91-90, 191-190	9
01-00, 101-100	10

Table B

The specific 20-line groups and associated start circuits of regular shelves that can be used for overflow service.

Line Terminals	*Start Lead Circuits*
21-20, 121-120	2
31-30, 131-130	3
41-40, 141-140	4
71-70, 171-170	7
81-80, 181-180	8
91-90, 191-190	9

Mounting Arrangement

The apparatus for a traffic grading overflow unit is mounted on a shelf 5′-10¾″ long, which provides a compact mounting for the circuit equipments and is arranged for mounting on all trunkboards used in exchanges having either Type 35E97 or Type 11 M-A-X equipment. It will also mount on the 5′-11″ wide trunkboards commonly used in Type 20 exchanges for mounting eleven-switch miscellaneous shelves. The adaptability of this shelf, coupled with the fact that it can be located anywhere in the office, allows maximum opportunity to utilize any vacant shelf space on existing trunkboards.

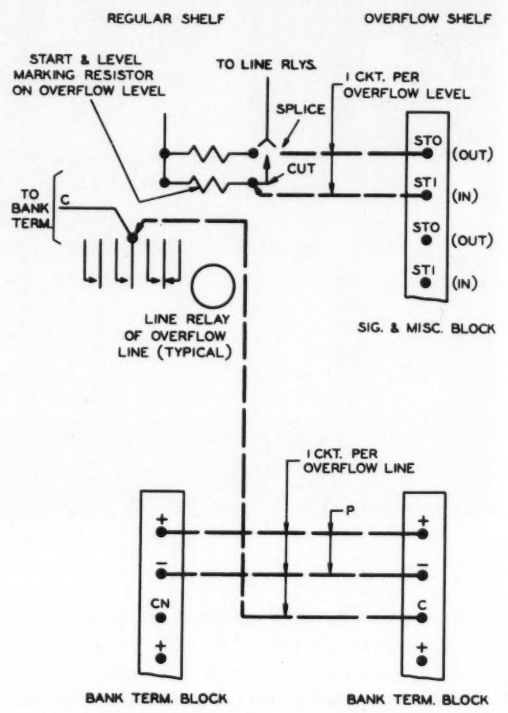


Figure 3. Method of cabling to regular shelf not arranged for overflow.

Figure 2 shows a typical overflow unit, and illustrates the mounting arrangement of the circuit equipments. The distributor rotary switch, the linefinders, and the group relays of linefinder group *A* are mounted across the upper section of the unit above similar equipments of group *B*. The transfer relays are located directly below the fuse panel shown at the left, and the "signal and miscellaneous" terminal block, to which the start leads are cabled, is mounted on the rear of the unit, behind the fuse panel. The 600 point bank-cable terminal blocks, to which the +, — and *C* leads of the overflow lines are cabled, are mounted vertically at the right of the unit. Bank designation cards (not shown) are mounted adjacent to the bank terminal blocks. These cards will indicate the location of "parent shelf" lines on the banks of the overflow unit.

The start lead transfer circuit is arranged to be

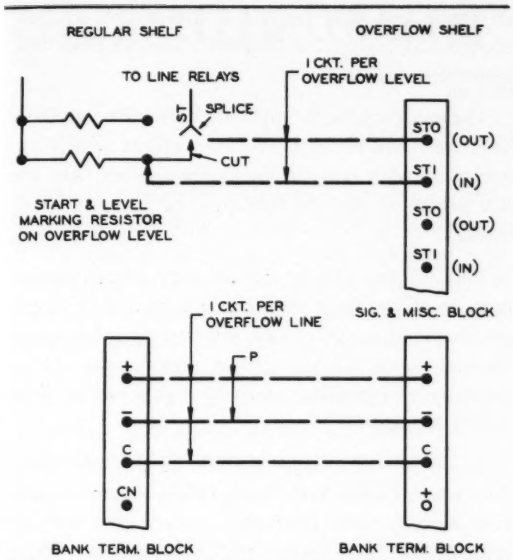


Figure 4. Method of cabling to regular shelf arranged for conventional 200 line overflow.

used in conjunction with most Automatic Electric linefinder circuits used in existing offices. Consequently, the typical overflow unit, shown on Figure 2, can usually be equipped with circuit equipments that are identical to those used on associated regular shelves. This is in keeping with operating companies' preference that they be supplied with circuits with which they are already familiar and which can be maintained and repaired from their present inventory of spare parts.

Cabling

The regular linefinder shelves that may require traffic relief fall into three general categories: (a) shelves not arranged for overflow; (b) shelves arranged for conventional 200-line overflow; and (c) shelves arranged for 20% line traffic grading overflow. The last named are specifically designed for use with the new type overflow shelves. For this purpose 40 lines have their start circuits brought out to a terminal block. The method of cabling the overflow unit to a regular shelf varies with the type of regular shelf; Figures 3, 4 & 5 are schematic diagrams showing the cabling required for each. The terminal blocks of the overflow unit are shown to the right, and the terminal blocks and affected circuit components of the regular shelves are shown on the left.

Figure 3 illustrates the method of cabling the overflow unit to a shelf that is not arranged for overflow. It shows how the finder start circuits of the regular shelf overflow lines must be opened at the start and level marking resistors and be connected to the start-in and start-out leads of the overflow unit. Since the *C* lead of the regular shelf is not brought out to a terminal block, it is necessary to multiple the *C* lead of the overflow unit to the regular shelf *C* lead at the appropriate spring of the line relays selected for overflow service. Figure 3 also indicates the number of leads required for each overflow line. For example, if 20 lines are to be given overflow service, 62 wires will be required. These wires will consist of 20 each of +, — and *C* leads, one start-in and one start-out lead.

Figure 4 shows the method of cabling to be used when the overflow unit is applied to a regular shelf that is arranged for conventional overflow. The cabling is the same as shown in figure 3 except for the wiring of the *C* leads. Since the *C* leads on a regular shelf of this type are

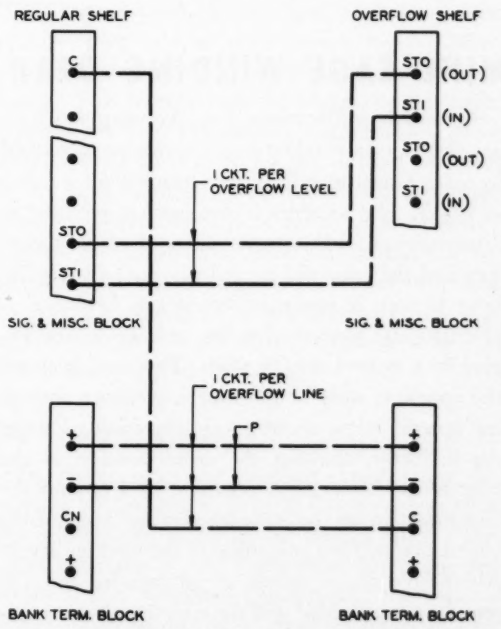


Figure 5. Method of cabling to regular shelf arranged for 20% line traffic grading overflow.

brought out to a terminal block, it is not necessary to wire to the line relay springs.

Figure 5 shows the simplified method of cabling, from terminal block to terminal block, that is possible when the regular shelf is arranged for traffic grading overflow service.

Summary

The traffic-grading overflow unit is an efficient and economical device which provides traffic relief to overloaded offices by serving a portion of the traffic associated with several 200-line linefinder shelves. It can be used in conjunction with most Automatic Electric Company linefinder circuits, and can be applied in exchanges where conventional means of traffic relief cannot be accommodated.

Since the new unit can provide traffic relief if and when an overload condition occurs, it makes it possible to furnish fewer extra linefinder bank positions on initial installations—which in turn results in a saving of floor space.

The new relief unit can be located anywhere in an office and thus permits a more compact and economical layout for linefinder shelves than was formerly possible.

The major present application for the new "relief" unit will be in overloaded offices which are equipped with regular linefinder shelves that are not arranged for the addition of overflow linefinders.

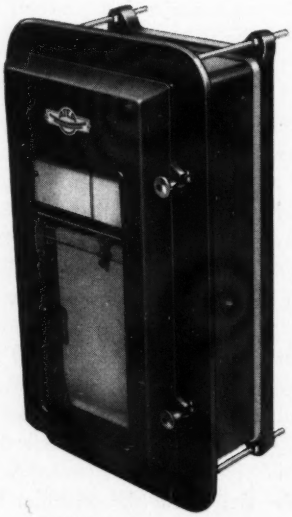
The unit can also be applied very advantageously to an office where shelf space is limited or where the overload traffic can be relieved by a few extra linefinders per 200-line group, and the use of one ten-linefinder-position conventional overflow shelf is not warranted.

In order to facilitate the use of the new overflow unit at some later date, offices can be equipped initially with linefinder shelves that are arranged for 20% traffic grading overflow. These shelves anticipate the possible future use of the new type of overflow service, and are arranged to make it convenient to apply the Traffic Grading Overflow Linefinder Unit, if and when an overload condition occurs.

MINE CAGE WINDING GEAR RECORDER

Automatique Electrique, S.A., Antwerp, Belgium, has developed a winding gear recorder as prescribed by many Governments in their legislation for safety in mines. The recorder is designed to provide an instantaneous and permanent record of the movements of the cage, day in and day out over the 24-hour period. A pen-type recorder is used and is mechanically connected to the actual winding engine by a geared driving shaft. The tracing shows the complete story of the cage movements including speeds, stops, duration and location of stops. An indicator, showing the exact position of the cage at any moment, is provided by a pointer device mounted on the recorder carriage and passing over a dial marked according to the working levels. Alternative paper speeds of 60 mm/hr and 120 mm/hr are provided and the chart, with rectangular coordinates, has a useful width of 110mm.

V. ANTHONIS, *Antwerp*



Winding Gear Recorder.

CENTRALIZED TRAFFIC RECORDING

By IMRE MOLNAR
Project Engineer, Automatic Electric Company

SYNOPSIS: *Importance of traffic recording—peg counts—switch counts —the portable Trafficorder—permanent installations — three plans — method of operation—traffic recorder design — special studies.*

FROM the earliest days of telephone operation, recording of traffic passing through an exchange has always been an important function of central office management. Scheduling of operators in manual offices, and the providing of adequate amounts of switching equipment in automatic offices must, of course, be based on the amount of prevailing traffic in order that a grade of service satisfactory to the customers can be maintained at all times.

Peg Counts

One of the simplest means of recording traffic is to count the number of calls answered by an operator, or the number of times a switch or a group of switches was used. If automatic peg counts are properly designed, they are capable of providing accurate data in respect to the number of times the observed switches were seized during the period of observation.[1] However, such data by themselves are inadequate to determine the *amount* of traffic carried by these switches, or the *amount* of traffic passing through the whole central office. For instance, a linefinder switch is seized not only by bona fide calls, but also by line permanents, handsets accidently removed, etc., and each such seizure is counted. Connectors are seized not only by calls which are completed, but also by unanswered calls or calls to busy lines, and each such seizure is counted.

Furthermore, the number of switches which must be provided for satisfactory service depends on not only the *number* of calls, but also the average holding time. If the average holding time has been determined separately by some means, peg counts will furnish the required traffic information by themselves; however, the most reliable way to obtain the average holding time is by measuring the traffic and dividing this by the number of calls. Therefore, traffic measurement is still the primary source of information.

Peg counts by themselves, without being supplemented by traffic measurements, may be misleading. They may give a useful comparison between several groups of switches, as to which group appears to be overloaded or underloaded relative to the others, but they will not reveal whether any of the groups are really adequate.

Switch Counts

In earlier years the method used for traffic measurement was to count every two or three minutes the number of switches in use in each group. This method was an adaptation of traffic measurements used in manual central offices, where every two or three minutes the number of cords in use were counted. To carry out such a program requires a sizeable clerical force; it is obviously subject to human error, and its accuracy is inherently limited.[2] In order to be sure of providing the correct amount of switching equipment, it is desirable to have traffic data accurate to 2 or 3%, but certainly within 5%.[3]

The Portable Trafficorder

In recent years the portable Trafficorder developed by Automatic Electric Company has been extensively used in telephone central offices. The input terminals of this Trafficorder are connected to the *C* (or "private") conductor of the switches under observation, and these conductors are scanned each ten seconds as to their state of occupancy. Each time a switch is found to be oc-

cupied, mechanical counters are advanced one step. At the end of the observation period (usually one hour) the total amount of traffic carried during that period is directly shown on the counters, in unit calls, to an accuracy of one-tenth of a unit call. The Trafficorder is capable of scanning up to a maximum of 500 trunks, arranged in twenty groups with a maximum of twenty-five trunks each. In addition to measuring traffic, the Trafficorder can also be used to determine holding times, delays, and other special data regarding various components in a central office.

Due to its mechanical reliability, frequency of scanning, and precision of timing, the Trafficorder provides a very high degree of accuracy. It is put into action by operating a start key, and the result is obtained by reading off the twenty counters at any convenient time after one hour. The only preparation to be made for a traffic recording program is to connect the trunk leads to the Trafficorder input. These remain connected until sufficient data on the trunks have been collected. In smaller offices the leads may remain undisturbed until the next observation program; in large offices the leads may be moved to another batch of 500 trunks to be observed, or several Trafficorders may be used simultaneously. Where there is a network of several smaller offices, one Trafficorder may be moved from one office to another to record the traffic consecutively in each of them.

Permanent Installations

Several methods have been tried to reduce or eliminate the labor of connecting and disconnecting the input leads each time different groups of trunks are to be observed. The only satisfactory method to accomplish this is the installation of centralized traffic recording equipment, such as that recently developed by Automatic Electric Company.

This equipment consists of a relay rack (or racks, depending upon the size of the office) where all the equipment needed for collecting complete traffic data from the office is concentrated. The leads from the switching equipment to the Trafficorder input are permanently or semi-permanently cabled; traffic recording can be initiated in groups, or all at once, by pushbutton operation, or completely automatically. The only labor involved is to read off (or photograph) the results from the counters.

The features and potentialities of this centralized traffic recording equipment will be more fully discussed later in this article. It might be useful to summarize at this point the advantages gained:

(a) For most efficient administration of a telephone plant, traffic conditions prevailing should at all times be known to management. Only in this way can the correct amount of equipment be determined, to insure that the quality of service is protected with the least amount and most efficient use of equipment. With permanently installed traffic recording equipment, complete data can be obtained continuously all year around or during any chosen period, and with only a nominal amount of effort.

(b) Regulatory commissions demand that a certain quality of service be given to telephone users, and allow the provision of sufficient quantities of switching equipment to give the prescribed quality of service for the prevailing volume of traffic. Documentary evidence derived from systematic traffic studies made by automatic traffic recording means, prove the adequacy of plant provisions.

(c) The most efficient use of switching equipment is obtained by proper balance of traffic between the various groups of switches. In addition to the day-to-day fluctuations of traffic, however, there are seasonal and other variations; therefore, traffic data taken on different groups of switches several weeks apart may not be comparable. To obtain the correct balance between all groups of switches, traffic data should be obtained simultaneously for all. Centralized traffic recording equipment makes this possible.

(d) The number of connections to be made to the permanently cabled traffic recording equipment is the same as is required to the portable Trafficorder, if the same number of switches are to be observed during an observation program. The installation cost of the permanent wiring should be, therefore, about the same as the cost of connecting the portable Trafficorder during, say, the first year of its use. The accumulated cost of

connecting, disconnecting, and reconnecting the portable unit during subsequent years may then be compared with the added initial cost of the centralized equipment, and this, over and above the added benefits from centralized operation, should "prove in" the permanent equipment.

(e) Some traffic observation programs are regularly (and properly) scheduled with only a few minutes' tolerance, while other programs may have to be carried out on very short notice, and with equally precise timing. In either case, the connection of portable Trafficorders usually requires work by plant personnel, which might interfere with other pressing duties at the very same moment. Since the operation of the centralized equipment is either fully automatic or at most requires only pushbutton control in addition to reading of a few counters, it can easily be performed by technically untrained clerical personnel assigned to the traffic department, without interfering with the regular duties of plant maintenance.

(f) Since the centralized equipment may be automatically started at a predetermined time every day, and stopped automatically after a predetermined time, the accumulated result may be read off all at once—at, say, the end of the week—which further reduces the amount of work involved in traffic studies.

(g) It is important that from time to time special studies be made on certain items—for instance, answering delays by operators, duration of all-trunks-busy periods, and holding times of important components such as directors, translators, senders, toll ticketing equipment, etc. These studies are usually required only at infrequent intervals, and could equally well be done with portable Trafficorders. However, the experience is that where only portable Trafficorders are available, their time is so fully scheduled that nothing is left for special studies, while with the centralized equipment sufficient spare capacity can be provided to take care of these.

(h) Traffic recording in many cases may supersede conventional peg counts. Where peg counts are still desired—for instance, for holding time measurements—they are completely integrated and synchronized with the traffic recording equipment, so that each traffic item will simultaneously provide the corresponding peg count. Furthermore, the equipment is so arranged that the peg counts may be operative independently during periods when there is no traffic recording program in progress.

The capacity of a centralized installation is unlimited, because the equipment is made up in self-contained units, and a sufficient number of units are simply assembled to suit any size of installation (or they may be added at subsequent expansions). As with the portable Trafficorder, each unit has a capacity of 500 trunks, arranged in twenty groups of twenty-five trunks each. It is complete with twenty-one counters and all necessary control equipment, with the exception of a separate, small, common timing unit which has sufficient capacity to take care of the largest anticipated installation. In addition, each unit may include all peg count registers associated with the switch groups connected to this unit, together with an arrangement for coordinating traffic records and peg counts. (Up to fifty peg count registers may be associated with one unit.)

Each unit may be individually started and stopped, or all units simultaneously. Starting can be automatic at a predetermined time or manually controlled, while stopping is always automatic, unless the control is set for "continuous scan", in which case the unit must be manually stopped.

Three Plans

In planning an installation of the centralized traffic-recording system for a central office, the first step is to decide on the scope of such installation. It may be a "fixed" system, in which every trunk is permanently accommodated within the recording equipment; or it may consist of one or two units to which the trunks are only temporarily assigned for the duration of a study, and periodically rearranged as the necessity arises; or it may comprise a number of units sufficient to accommodate permanently those trunks which should be constantly observed, and in addition provide some spare capacity for temporary assignment to the trunks which are to be only occasionally studied.

The first method is, of course, the best arrangement, for it incorporates all the advantages previously discussed. Considering that all connections

are made by permanent office cabling at the initial installation, which need not be disturbed during the life of the equipment, its cost can probably be justified in all cases where the cost of systematic traffic observation is justified. The equipment need not take care of all switching ranks of an office, since the traffic in certain "cross-sections" of an office can readily be determined from the traffic in preceding or succeeding cross-sections. For instance, the traffic in the rank of selectors preceding connectors will be the same, to an adequate approximation, as the sum of the traffic in the connector groups connected to the banks of those selectors. In an office with three ranks of selectors it is sufficient to measure the traffic on line finder groups, on connector groups, and on second selectors. In addition, all outgoing and incoming interoffice trunks should be observed (unless this is done at the distant end), as well as toll recording and toll switching trunks, reverting call switches, special services, toll ticketing equipment components, and other special items. A modest amount of spare capacity should also be provided for special studies, but usually such spares will automatically be available, since only by coincidence will all units of 500-trunk capacity be completely filled.

In a typical case of a 10,000-terminal central office in a single-office area, with automatic toll ticketing and a modest amount of trunking to its toll center, the complete permanently cabled traffic-recording equipment required nine units, with a total of about 100 peg count registers. Another 10,000-terminal office in a very large metropolitan area with very heavy local and interoffice trunking, as well as an unusually large volume of automatically ticketed toll traffic, required thirteen units.

The second method of installation may use only one or a very few units. The inputs of these units are permanently cabled to a trunk distribution frame, where jumper connections are made to the *C* conductor of the switches to be observed. The jumpers may remain as long as data are being collected on the same group of switches, but must be changed each time new batches of switches are to be studied. Obviously, the only advantages of this method over the use of portable Trafficorders are the fixed location of the units, permitting a more orderly way of arranging the input connections, and the ease with which it is expandable into the first or third methods.

In the third arrangement some of the units are permanently filled with those trunks which are expected to be under constant surveillance (or which, at least, should be readily accessible). These may be connected by permanent office cables, or through the trunk distribution frame, as described above. The rest of the units, reserved for periodic observations, have their input leads cabled to the trunk distribution frame, where jumpers may be rearranged each time a new group of switches is to be studied. A typical example of this arrangement is a medium-sized toll center where four units and about 180 peg count registers are provided. Two of these units are filled with permanently connected leads for the information which must be continually kept up; this includes the inward and outward traffic on toll lines, the answering delay of operators, and the average occupancy of operators. The other two units are available for periodic observations, on a semi-annual rotating-schedule basis. These include traffic studies on toll recording, toll switching and operator trunks, senders, intertoll selectors, automatic call distributing switches, connecting links and a few other miscellaneous items. There are a sufficient number of peg count registers so that all groups of switching components are permanently assigned to separate peg count registers.

Method of Operation

As mentioned earlier, this method of traffic recording (See Figure 1) requires a periodic scanning of each circuit as to its state of occupancy at each scan. If the circuit is unoccupied it is passed up until the next scan; if it is busy the associated counter registers one count. Each counter, then, will indicate at the end of the observation period the total number of times the connected circuits were found busy in all scans during the observation period.

In the system described in this article each trunk is scanned every ten seconds; therefore 360 scans are made in one hour. If a trunk were continuously in use during that hour, it would cause the counter to register 360 counts. A trunk continuously in use carries 36 unit calls, and proportionally less in ratio

to the time it was actually in use. Thus a counter will register ten counts for each "unit call" (100 seconds) of trunk usage, and the indication on the counters after one hour of operation will be equal to ten times the traffic (in unit calls) carried by the trunks connected to the scanning device during that hour. The traffic can be obtained directly from the counters, in unit calls to an accuracy of one-tenth of a unit call, by subtracting the counter indications at the start of the period from the indications after the equipment stopped at the end of the hour. To distinguish the decimal point after the unit call, the right wheel of the counter is of contrasting color from the other four.

The capacity of each counter is 10,000 unit calls. Twenty-five trunks, if in continuous use, would carry nine hundred unit calls; therefore, even under the most unlikely circumstances, a counter will not turn over completely within eleven hours. Thus the equipment can be left running unattended two hours each day for five business days.

One lead from each circuit under observation is connected to an input terminal of a recording unit. As the traffic-recording equipment responds to ground potential, this lead must be grounded when the circuit is in use, and must otherwise be ungrounded. In automatic telephone systems the *C* (or "private") conductor of a switch or other circuit satisfies this condition; it is, therefore, natural to use it for traffic-recording purposes, particularly since in most cases it is readily accessible at some distributing terminal point for cabling to the traffic-recording equipment. The equipment is so designed that it will not interfere during scanning with the normal operation of the circuits under observation. In the very rare case that the *C* lead is unavailable or unsuitable for the particular purpose of the study, some other point usually can be found which is grounded during the period of interest and can be extended to the recording equipment. (In recent circuit designs, particular attention has been paid to the selecting of certain pertinent points and making them accessible for traffic observation.)

Each traffic-recording unit is capable of observing twenty groups of twenty-five trunks each, and each counter can register the unit calls carried by such a group of twenty-five trunks. The number of trunks assigned to each group obviously depends, however, on the size of group which can conveniently be observed: the traffic on all line finders in a group of two hundred lines should be recorded on one counter; or, if it is desired to know the traffic in each connector group individually, only the connectors belonging to the same group should be assigned to a counter, even though their number may be less than twenty-five. Conversely, if the number of trunks in a natural group exceeds twenty-five, they should be split up among two or more counters, and the sum of their readings will give the traffic of the whole group. (The twenty-first counter on the recording unit indicates the number of scans performed.)

The scanning device checks twenty leads simultaneously, in twenty-five consecutive steps spread out over the ten-second cycle. This cycle repeats itself until the end of the observation period. The observation period may be pre-selected to cover one hour, two hours, or three hours—that is, 360, 720, or 1080 scans, respectively; at the end of the observation period, scanning stops automatically. "Continuous scanning" may also be pre-selected, in which case the ten-second scanning cycles repeat themselves until manually stopped.

Traffic Recorder Design

In the design of the scanning control circuit, great care was taken to insure exact timing and regularity. The "scan width" (that is, the length of the scanning pulse) was reduced to a minimum consistent with reliable and positive operation of the counters. Narrow scan width increases accuracy by reducing the probability that a circuit will become occupied, or be released during the period of the scanning pulse.[4] Precautions are also taken that neither the first nor the last scans are in any way clipped, and that all functions of a unit are rigidly synchronized.

Each unit has its own control switch, by means of which the unit can be turned on and off independently of the other units, with the length of the observation period pre-selected; or it may be preset to automatic start control. Any number of units can be pre-selected for simultaneous start, the remaining units being started at any arbitrary moment. Simultaneous starting of several units

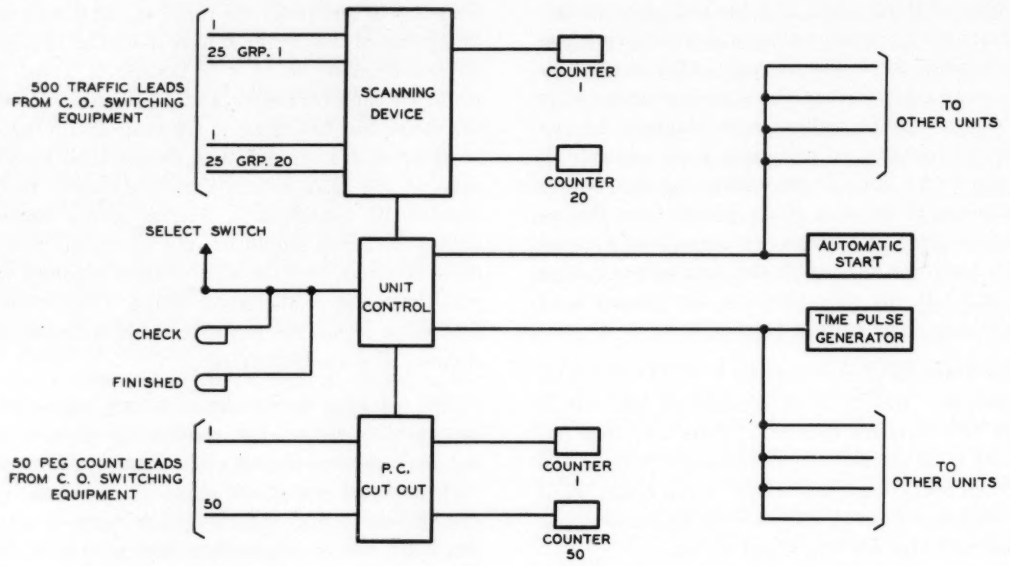


Figure 1. Schematic Diagram.

may be manually or automatically controlled. The timer of the automatic starting device can be set so traffic recording commences each day at exactly the same clock time.

Two supervisory lamps are provided with each unit. One indicates that recording is in progress, and also that scanning is proceeding in an orderly manner; the other lamp lights after the observation period is completed.

There is a small time-pulse generator common to all recording units, for timing the length of the scanning cycles as well as the width of scanning pulses. This unit is likewise arranged for manual or automatic start and stop.

As previously mentioned, up to fifty peg count registers may be associated with each traffic-recording unit. The assignment of these peg count registers is such that they provide the peg counts of the same group of trunks as are assigned to the same traffic-recording unit. Of course, the number of peg count registers may be higher than the number of traffic counters in the unit, in case different functions of a trunk group are separately counted.

Normally, the peg count registers are extended to the peg count leads of the switch circuits, and the peg counts are continually registered. To synchronize peg count and traffic registration on the same unit—for the purpose, for instance, of establishing the average holding times—peg counts are momentarily stopped just prior to the commencement of the traffic-recording period, and readings are taken from the peg count registers. Following this, with the start of the observation period, the peg count registers are automatically reconnected to the peg count leads, and both traffic and peg count records progress until the end of the predetermined period. When the traffic-recording unit stops, the associated peg count registers are again automatically disconnected, so the final reading can be taken when it is convenient. After resetting the unit, the peg count functions are restored to normal.

Arrangements are provided so that when a traffic-recording program covering the busy hours of several consecutive days is initiated with auto-

matic start each day, the peg count registers are automatically disconnected between observation periods. However, there are also provisions for making this disconnect feature inoperative on any one of the peg count registers, so that peg counts are continually available, irrespective of whether traffic studies are simultaneously in progress or not.

Each unit of centralized traffic-recording equipment is self-contained, including counters, scanning device, scanning control, start switch, and lamps. The layout is shown in Figure 2. The unit is 1′7-7/16″ high, and 1′11¼″ wide. The external cable for the five-hundred input leads is connected to a ten-by-fifty terminal block on the unit. The peg count registers may be mounted above or below, or separately from, the unit, and require 4¾″ height per strip of twenty registers. The time pulse generator and automatic start equipment, common to all recording units, needs only 1′0¾″ rack space. All units are mounted on standard 2′0⅜″-wide relay racks.

Special Studies

Reference was previously made to special studies which may be performed with this traffic-recording equipment. They usually involve either registration of occupancy, or peg counts of the function to be studied, or both. The equipment described in this article can almost universally be used for such purposes because of its simplicity, automatic operation, and ease of evaluation and interpretation, and because the frequency of its scanning cycles assures a sufficient degree of accuracy for even very short occupancies. The frequency of scanning can further be increased by multiple-strapping the input terminals, and then dividing the counter readings by the number of multiple appearances. For instance, if only ten trunks in a group are to observed, they may be connected to two sets of ten input terminals in the same group of twenty-five terminals (with five terminals left spare), thus providing a five-second scanning cycle. There is no hard-and-fast rule as to the exact arrangement of equipment for such special studies; each case must be separately determined. However, the following two examples may serve to illustrate the principle.

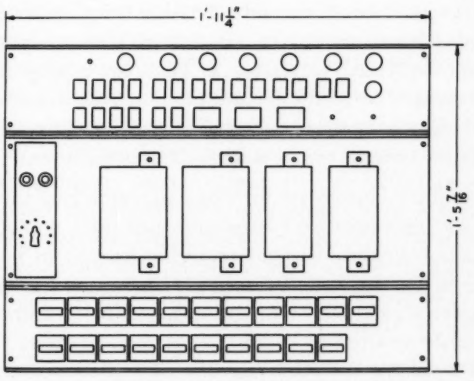


Figure 2. Equipment Layout.

An operator's delay in answering a call is obviously measured by the length of time that an answering lamp in the switchboard multiple is lighted. The answering-lamp multiple may be controlled by a relay, the coil of which is grounded from the time a call arrives until it is answered—or it may have an accessible "make" contact spring which is grounded during that time. Such a lead is to be extended to an input terminal of the traffic-recording equipment, and a sufficient number of such trunks should be so extended to provide in a reasonably short time statistically meaningful data. The traffic-recording counters will show the total amount of answering delay on these trunks during the period under observation, and if simultaneously the number of calls carried by the same trunks are counted on the associated peg count registers, the average answering delay experienced during that period may be found by dividing the total delay by the number of calls. Average delays are convertible into standard figures for the grade of service.

It is sometimes of interest to know the average holding time of sender equipment, and also, separately, the time taken to register input digits to the senders, and the time taken to transmit the digits out of the senders. The sum of the last two will not be equal to the total sender holding time, since these functions partially overlap. To determine the three holding times separately, three leads are to be extended from each sender to the traffic-recording equipment—one being grounded during the occupancy of the sender, another while digits are being received, and the third while

digits are being transmitted. The three sets of leads are to be connected to separate groups of input terminals on the recording equipment. If peg counts are made on these senders simultaneously, "average holding time" data on each of the three operations will be obtained. Furthermore, another peg count lead might be connected to count each time a digit is registered in the sender; the reading on this counter divided by the reading on the regular sender peg count meter will give the average number of digits received each time a sender is in use. Various other data pertaining to sender operation are just as easily obtainable, limited only by the need of, and desire for, such information.

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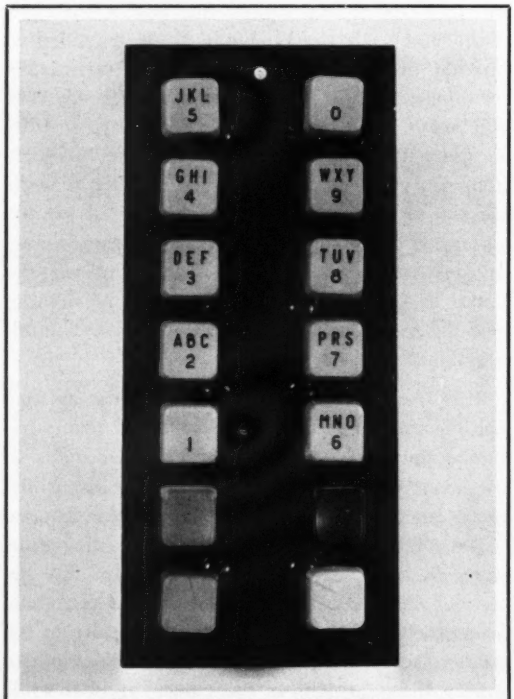
4. On the Accuracy of Holding Time Measurements. Imre Molnar. *The Automatic Electric Technical Journal*, Vol. 3, No. 2, April 1952. Also *AIEE Transactions*, Vol. 70, Part II, 1951, pp. 1912-1918.

NEW MOLDED BUTTONS FOR KEYSENDERS AND PUSH KEYS

Following the established tradition of Automatic Electric Company to strive constantly to improve its products, a new "look" in buttons for keysender equipment used on manual switchboard positions has recently been announced.

The newly designed button is molded of Tenite II by the "double injection" process, which produces molded parts in two colors. In the process the mold is first closed with inserts in place and filled with plastic of a chosen color. The mold is parted and the inserts are removed. The button is then reassembled and voids resulting from the removal of the inserts are filled with plastic of a contrasting color. The final product is a brilliantly outlined figure, which will retain its legibility for the life of the button.



Keysender Using New Molded Button.

As shown in the accompanying photograph, the new button has a square face with slightly-rounded corners. The face of the button has a slight depression for centering the fingers by touch. The color chosen for the ten digit keys is gray background with contrasting black characters. Because of the rapid conversion to toll dialing, metropolitan letters and numerals will appear on the buttons.

In addition, four solid-colored buttons are available without characters. The "error" button is black and the "start" button is red. These are readily distinguished by both color and position. Also available is a blue button and a gray button for auxiliary keys on the bottom two keys of the 14-button keyset.

All the buttons are mechanically interchangeable with corresponding buttons presently used, and will mount securely without requiring cement to hold them in place. A full set of 12 buttons can be ordered as D-59271-A, and a full set of 14 buttons can be ordered as D-59271-B. A tool, H-881419-1, is available for removing the old, cemented-type buttons.

L. W. O'GRADY, *Chicago*

A FULLY AUTOMATIC TELETYPEWRITER SWITCHING CENTER FOR MILITARY USE*

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Project Engineer, Automatic Electric Company

and R. C. STILES
Project Engineer, Automatic Electric Company

SYNOPSIS: ***Characteristics of military messages — switching center specifications — general system description — sequence of operation — equipment description — the multiple call system — conclusion.***

THE U. S. Army Signal Corps has added another chapter to the colorful history of military communications. On December 17, 1952, at Headquarters Fifth Army, Chicago, the Signal Corps placed in service its new teletypewriter switching center which automatically switches messages through the Army's vast, world-wide, teletypewriter network. Sufficient time has passed since the system was cut into service to provide adequate demonstration that the system is an important link in modern military communications. Behind the drama of the cutover to the new system lies a story of technical progress which has kept the U. S. Army Signal Corps abreast of the most modern developments in communications technique. Some of the many technical and operational problems encountered in the development of this highly complex system will be told here.

The story of the teletypewriter art is one which parallels to a certain extent the development of the telephone art. The first attempts at teletypewriter switching centers saw the manual interconnection of lines by an operator for point-to-point communication just as in the early days of telephone communication. As the art swung toward the transmission of separate messages, more elaborate switching centers were employed to route messages toward their ultimate destinations. The first commercial automatic switching centers were installed just prior to World War II. These centers were capable of receiving mesages and automatically routing them toward their several destinations without the assistance of operators. Thus a teletypewriter switching center is similar in purpose to an automatic dial telephone system. One such system for commercial use has been described by Messrs. W. M. Bacon and G. A. Locke in the transactions of the American Institute of Electrical Engineers.[1]

During World War II, teletypewriter communication assumed new importance. It was during this period that the military commands began to use large-scale networks of teletypewriter channels and equipment to facilitate their task of extending communications on a world-wide scale. The networks which were formed for the military commands consisted of both Government-owned radio facilities, and lines or channels which were leased from commercial companies on either a full-time or a part-time basis and which were terminated in teletypewriter equipment which was largely owned by the Government and operated and maintained by personnel of the various commands. To minimize the number of lines required, each network contained a number of switching centers, which functioned in these networks in much the same manner as a telephone central office functions in a telephone system. Each teletypewriter station was connected to a switching center either by a direct line or in some cases by means of a party line which served several stations.

One of the principal differences between a telephone system and a teletypewriter system, however,

*A paper presented at The Winter General Meeting of the American Institute of Electrical Engineers at New York, N. Y., January, 1954. Reprinted by Permission.

1. A Full Automatic Private Line Teletypewriter Switching System. W. M. Bacon and G. A. Locke. *AIEE Transactions*, Vol. 70, Part I, 1951, pp. 473-480.

lies in the type of message to be conveyed from one point to another. The telephone requires point-to-point contact, but a teletypewriter message may be transmitted from its point of origin to one of several intermediate points where it may be reproduced for subsequent re-transmission when the required circuits become available.

The equipment in use at these switching centers during World War II was of the manual type, which required that a message into a switching center be reproduced on a printed and perforated paper tape. An operator was required to read the address code of a message and, following complete receipt of the message, was required to place the message tape temporarily in a storage rack. Subsequently an operator was also required to withdraw the message from storage and insert it into a transmitter as the appropriate line became available. This manual process frequently caused delays and also created a complex problem of personnel handling.

Following World War II, the U. S. Army Signal Corps began a search for newer and more efficient switching-center equipment to put their networks on a permanent basis. The Signal Corps recognized that the task of switching a message to temporary storage, and subsequent re-transmission, could be accomplished automatically by the use of techniques commonly used in the art of automatic telephony. An examination of existing commercial systems showed these systems to be inadequate for Army requirements, and the Signal Corps prepared a specification covering a switching center which would meet those requirements. The system described in this paper was developed to meet the provisions of that specification.

Characteristics of Military Messages

Before considering the characteristics of the equipment required to switch military messages the reader should have an adequate understanding of the types of messages involved in a military network. Military messages range in length from very short messages such as the average telegram message to long messages involving requisitions, reports, troop movement data, logistics reports, and even public relations information which is to be given to the press. Interspersed between these longer messages are also the extremely short ones dealing with the operation of the network itself. Messages of this type usually use three-letter operating signals to indicate a particular situation, such as, for example, the use of the operating signal ZDK to instruct a switching center operator to rerun a particular message for checking purposes. This wide range of message lengths is an important factor in the design of equipment. The average military message, however, is considerably longer than the average commercial message, thus accounting partly for the need for special equipment.

Military networks are used by nearly all types of military installations. It is not likely that front-line or even rear-area troops deployed in a tactical situation would be using the facilities of a teletypewriter network which would use automatic switching, but behind these tactical troops are the many administrative and supply organizations which must keep in constant communication with the zone of the interior. For these communications, the written word and speed of service are highly important. Within the zone of the interior, many types of military activities such as training commands; army posts, camps, and stations; recruiting centers; and supply points and depots, use the networks to good advantage. Most of these stations are equipped with network facilities only when the volume of traffic to or from the station warrants the leasing of line facilities, thus insuring that most of the lines into a switching center will carry a reasonably heavy load of message traffic.

One of the prime considerations in the network is the highest degree of reliability, and it is primarily this factor which determines network procedure, message format, and equipment characteristics. (Seldom in a commercial network does life or death to many men, or the success or failure of a major undertaking such as military operation, depend upon specific messages being delivered to the proper addressee). This same consideration also is closely coupled to the need for particular messages being given priority over others. Thus in a military network the relative degree of precedence assigned to a message by its originator must be recognized and adhered to in the switching centers. Messages of extremely high precedence actually require interruption of messages of lower precedence to clear the way for the high precedence mes-

sage. This particular characteristic of a military network is of utmost importance in the design of automatic switching center equipment.

In a network which operates on a world-wide basis it is most convenient to use a plan of station call-letter assignments in which the call-letter assignment itself identifies the activity and its approximate geographical location. The first consideration is the identification of the network, since in modern military operation all services which operate their own networks must also be able to transmit messages of all other services. Joint agreement, therefore, has assigned the first letter of a station call sign, known as a routing indicator, to identify the service network involved. Since all of our military networks are composed only of switching centers each of which serves local nearby stations, the next point of consideration is the geographical location of the switching centers. For this purpose the world has been divided into a number of areas to each of which a definite letter has been assigned. Thus the second letter of a routing indicator serves to identify a particular area of the world. The third point of consideration is the particular switching center within the designated area and network. Thus the first three letters of the routing indicator identify a particular switching center. Succeeding letters of a routing indicator serve to identify a particular tributary station of the designated relay center. The routing-indicator assignment plan is therefore of utmost importance to the design of the switching-center equipment. It is also important that each of the number of degrees of precedence of a message be indicated by a specific precedence indicator. Both routing indicators and precedence indicators must appear in the routing line or address portion of the message.

Switching-Center Specifications

The specifications covering the design of the switching center were highly exacting. One of the most basic of the requirements was that the new switching center should take fullest advantage of existing teletypewriter equipment. This was necessary because the Army had a considerable amount of money already invested in teletypewriter apparatus which was usable. This requirement limited the new center as to the type of apparatus to be used, and fixed the network transmission speed at the capabilities of existing equipment, which was approximately 60 words per minute. Another basic requirement was that the new equipment should be capable of conforming to the then existing message format. It also was to be capable of installation at any switching center of the network without installation of similar equipment at other centers. These two requirements made it necessary for the new switching center to be capable of directly replacing any one of the switching centers in the network. The reason for this was that the first center was to be of an experimental nature, and the Signal Corps preferred not to permit the experimental switching center to compel alteration in the network procedure and message format in the entire world-wide network. From a practical standpoint these requirements meant that the equipment must read the address portion of the message after it was perforated in a paper tape at the switching center and act upon it accordingly. One deviation from the standard message format which the Signal Corps permitted was the addition of a "start-of-message" indicator at the beginning of a message and an "end-of-message" indicator at the end of the message. Some commercial systems do not use a start-of-message indicator, but it was felt that in the Army system the start-of-message indicator was necessary to safeguard message sequence. Since a message might pass through several switching centers en route to its destination a further requirement was that none of the routing information could be absorbed in a switching center, thus insuring that succeeding switching centers would have complete routing information.

Because of the importance of military messages the system had to be engineered for a maximum degree of reliability. Adequate provisions were to be incorporated into the system to insure that no message would ever become lost. The equipment was to be so well interlocked that equipment failures of any kind which might result in a lost or delayed message would be brought to the immediate attention of a supervisor. (As a safeguard against lost messages in the early manual systems, each transmission of a message between two points was assigned a serial number which served as a basis for checking the receipt of all messages passing through the networks. A similar system was to

be retained in the new system but was to incorporate automatic checking of the numbers.)

General System Description

Figure 1 shows a general view of the Fifth Army Headquarters teletypewriter switching center. The layout of equipment falls into two general classes. The first of these is the operational equipment—that is, those components which are normally used by operating and supervisory personnel in the regular performance of their duties. The second is the switching equipment, which normally is unattended. There were several factors which influenced the decision to follow the plan of separating operating and switching equipment. One of these was the type of equipment to be used; it was decided that electromagnetic switching equipment would be the most satisfactory, the most economical, and the easiest to use. A further consideration in the use of this type of equipment was that Signal Corps automatic telephone central office maintenance personnel would have the required background to learn quickly the circuitry of the new center.

The switching equipment can be basically divided into two classifications—the actual switches required to establish signal connections, and the relays required for tape reading, temporary data storage, and control purposes. The rotary switches are of two types. The first is a Type 45, multi-level, 25-point, electromagnetically operated stepping switch. Switches of this type are used primarily for the actual switching of signal circuits within the center but are also used for control functions. The other switch used is the Type 44, multi-level, 10-point switch. Switches of this type are used primarily for counting (for which they are especially well adapted since the 10-point continuous movement lends itself to cascading of switches to record a plurality of digits). They are used also in many places as a straight selector switch for control purposes.

The relays used are also of two types. The first of these, Type 57A, is the quick-acting, multi-contact

Figure 1. General View of Teletypewriter Switching Center In Operation at Fifth Army Headquarters, Chicago, Illinois.

type using twin contacts for maximum dependability. The versatility of this relay was used to great advantage to obtain the desired operating characteristics of the circuits. Since much of the tape reading was accomplished on a character-by-character basis by these relays, they had to be fast in operation and release, and had to carry a large number of contact springs. A further consideration in the selection of this relay was its extremely long life. Since many relays in the system must operate once for each character received on *any* incoming line, on a 24-hour basis, relays of rugged character were essential. Many relays in the system have as many as twelve separate sets of contacts, and thus it was imperative to choose a relay capable of satisfactorily operating over long periods of time with such a large load.

The other type of relay used in the system, the Type 58A, has roughly half the size and contact spring capacity of the Type 57A. Two of the relays are mounted in a space equivalent to one Type 57A. This relay was chosen to conserve mounting space where necessary. It is ideally suited for use as a data storage relay, since such relays generally require few springs and are used in large numbers.

A further consideration involved in the separation of the operational and the switching equipment was the decision to use common control equipment to the greatest possible extent. Here the principles which have been proven in automatic telephone exchanges were used to good advantage. Since it is basically uneconomical to use, throughout the entire length of a message, the large amounts of equipment that are required to establish a connection, the equipment used for this purpose was grouped together and made available to all components as required. Thus the total amount of switching equipment was materially reduced by the extensive use of common equipment. A further reason for using common equipment was the fact that by its use equipment quantity becomes a function of traffic rather than of the number of terminal facilities in the center.

Another factor which influenced the decision to separate operating and switching was the "packaging" requirements of the specification. The system was to be designed as a basic 25 line switching center, capable of expansion to a maximum of 250 lines by the addition of similar components. Wiring the banks of selector switches to a common multiple would obviously be uneconomical if the switches were located in different parts of the center, but when switches are packaged together installation becomes simple, since most wiring has been done at the factory. The coupling together of additional switching cabinets to accommodate an expansion of the system is a relatively simple matter. A switching unit of this type is shown in Figure 2.

The operating components consist of the Incoming Line Unit, the Cross Office Unit, the Automatic Numbering and Monitor Unit, the Cross Office Intercept Unit, the Incoming Line Intercept Unit, the Intercept Manual Forwarding Unit, the Multiple Call Storage Unit, and the Supervisor's Console. Also associated with the operating equipment but not directly coupled to it are teletypewriter devices for initiating new messages and keeping the necessary supervisory records.

Sequence of Operation

A general understanding of the operation of the system can be obtained by following the block dia-

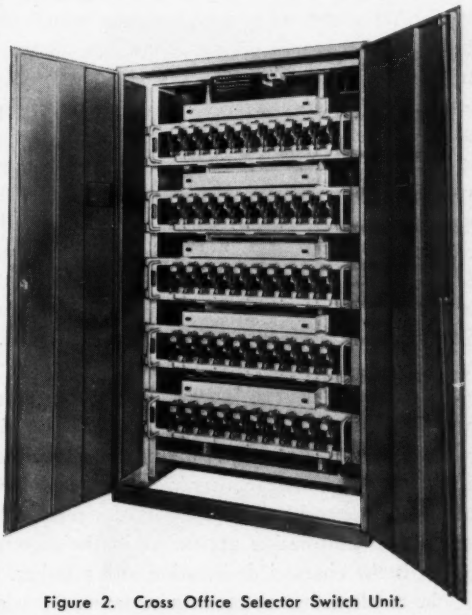

Figure 2. Cross Office Selector Switch Unit.

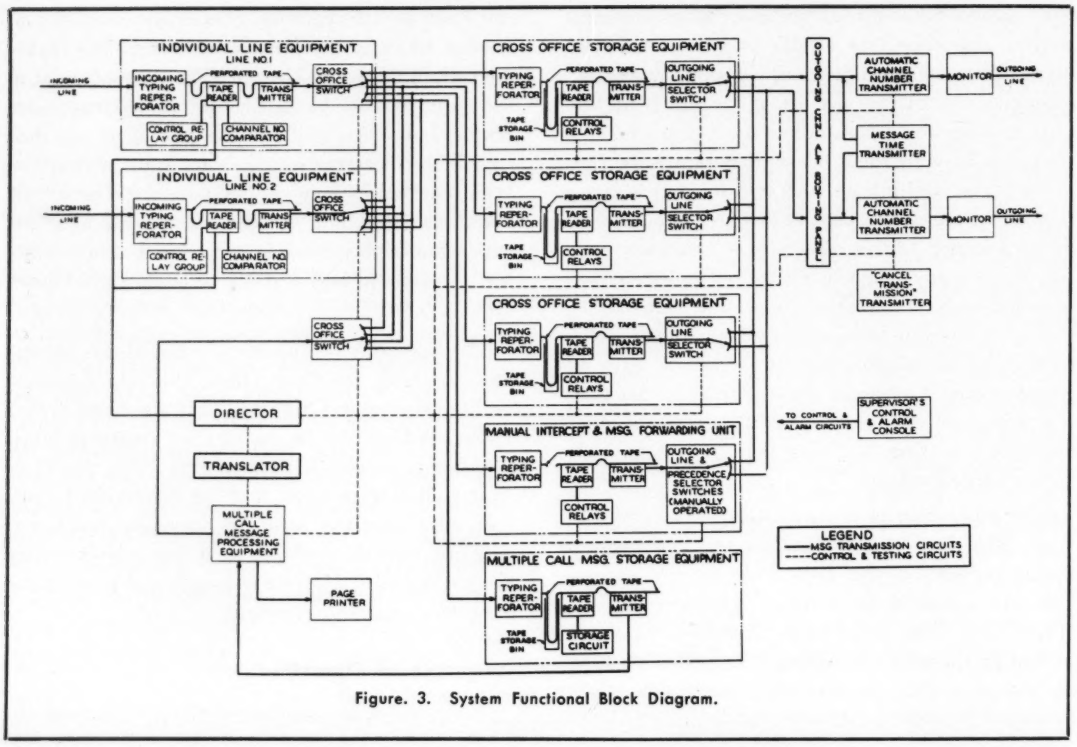

Figure. 3. System Functional Block Diagram.

gram of Figure 3, and by considering the flow through the center of several messages which will illustrate the sequence of operations. The incoming lines pass through terminal and patching equipment (which is not shown) and terminate in typing reperforators in the incoming line unit. The typing reperforator reproduces the message on a paper tape both in typed form and in perforations in the tape. As the tape between the reperforator and the reader slackens, the tape reader senses each character in the tape and passes along an electrical indication of the characters to the associated control relay group. In this manner the tape reader and the relay group cooperate in reading the tape. A relay sequence register in the relay group scans each character and records certain ones. When the sequence which is the start-of-message indicator arrives, the sequence register detects it and indicates its presence by the operation of a relay. The next bit of information appearing in the message format is the channel designation and number. It may be recalled that succeeding incoming messages on a given line are numbered serially. The channel number comparator has recorded the serial number of the last message received, and has thus been pre-set to record and check the serial number of the new incoming message. If the number in the comparator does not agree with the number on the incoming message, further processing is halted and an alarm condition is indicated. If, however, the numbers *do* agree, processing of the message is permitted to continue.

Checking of the channel number is a signal for the line circuit to call for the services of a Director (Figure 4). In response to that call, an idle Director finds and associates itself with the calling line equipment. Following this, the reading of the tape by the reader is permitted to continue, and each character read is recorded on relays in the Director. The Director, in scanning each character read by the reader, is hunting for one of several possible sequences of letters which will constitute a precedence indicator. Following receipt of this indicator other relay sequence registers are used to detect and register a routing indicator. These

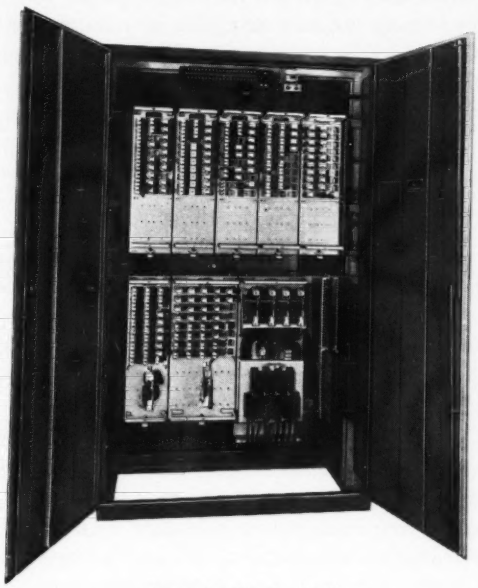

Figure 4. Director Unit.

relay registers are unique in that they have the ability to select a bona fide routing indicator from an indiscriminate group of characters, thus not relying on the relative position of the indicator in the message format.

When the routing indicator has been received, no further information is required from the line circuit. Receipt of the indicator also initiates a call by the Director for the services of the routing Translator. The routing Translator is an all-relay device which receives from the Director a coded three- four- or five-character routing indicator, translates that information, and sends back to the Director an indication of the outgoing line to be used for the message bearing that particular routing indicator. This translation process requires approximately 50 milliseconds, and, since the Translator is used for such a short time, only one is required—common to all Directors in any switching center consisting of one hundred lines or less.

Having received a line identification from the Translator, the Director must then select a cross office unit (See Figure 5). These units are arranged in a common pool of equipment; that is, no unit is permanently connected to any incoming line unit or permanently connected to any outgoing line. A cross office unit is temporarily associated with an incoming line unit via the action of the cross office selector switch which is associated with an incoming line unit, and it is temporarily connected to an outgoing line via the action of its own outgoing line selector switch. When a cross office unit has been associated with an outgoing line, it remains set to that line until all messages in it have been transmitted, following which its outgoing selector switch is reset. The unit is then returned to the pool and is again available for seizure for a new outgoing line. While a unit is set to an outgoing line it may receive many messages which are destined for that particular line, providing the unit also has been set to the desired degree of precedence. Two messages of different degrees of precedence are never directed to the same cross office unit while the outgoing selector switch is set to a particular line.

During the process of selecting a cross office unit the Director may make several tests of the cross office pool. The first of these is to determine whether or not there is already at least one cross office unit preset to the desired outgoing line and the desired degree of precedence. If there is at

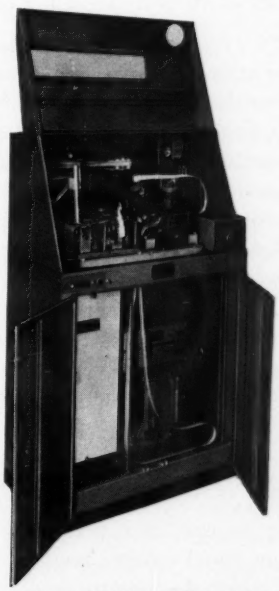

Figure 5. Cross Office Unit.

least one such unit and it is not busy receiving a message from another incoming line unit, the Director may cause the incoming line selector switch to be positioned to this unit. If the Director does not find such a unit, one must be selected from the pool of units. The process of selecting a new unit involves setting the cross office selector switch to a unit which is available, and subsequently setting the precedence switch of the unit to the desired degree of precedence and also setting the outgoing line selector switch to the desired outgoing line. Following this the unit is ready to receive the transmission from the incoming line unit.

When the cross office unit has been properly set, the Director has completed its functions. Its last operation before release from the connection is the transmission of a signal to the incoming line unit to cause it to assume holding control of the connection to the cross office unit. This signal also causes the transmitter to commence transmission of the message to the cross office unit. Transmission to the cross office unit is at the rate of 75 words per minute, which is sufficiently faster than the 60 words per minute speed of the incoming reperforator to quickly eliminate the tape which accumulated during switching. When the backlog of tape has been eliminated, transmission continues at the rate of 75 words per minute but on an intermittent basis.

When the start-of-message indicator has been transmitted to the cross office unit it is advanced immediately, in the case of seizure of a new cross office unit, to the tape reader, where the start-of-message indicator is read by the tape reader and detected by the associated relay group as in the case of the incoming line unit. After detection, the start-of-message indicator is advanced to a point immediately beyond the transmitter, at which time the reader and transmitter are stopped. At this time the associated relay group tests the condition of the outgoing line to determine whether it is busy or idle. If found to be idle the line is immediately seized by the cross office unit, thus preventing seizure of the line by another unit.

Before the transmitter is permitted to proceed, a transmission serial number must be transmitted to the line. Since this number is peculiar to the line and not to the cross office unit, the transmission must be controlled from line equipment. For this purpose the automatic channel-number transmitter transmits first the start-of-message indicator, and then the channel designation and serial number. Immediately following transmission of the number, control of the line is returned to the cross office unit for transmission of the message. When the end-of-message indicator is sensed by the reader and detected by the relay group, the tape is advanced through the transmitter to a point where the end-of-message indicator has been advanced to, but not through, the transmitter. At this point the cross office unit releases from the connection, and the automatic message-time transmitter transmits to the outgoing line the time of day, followed by the end-of-message indicator.

In the example described above, the cross office unit found the outgoing line to be idle when tested, which resulted in immediate seizure of the line. Had the cross office unit found the line busy, a further test would have been made to determine the precedence assigned to the line by some other cross office unit. Having obtained an indication of this precedence, the cross office unit would have then made a comparison of the line precedence with its own precedence. If the precedence of the line at the time was low and the precedence of the cross office unit was sufficiently high (one of the three highest) the cross office unit would interrupt the outgoing message. (It will be recalled that in a military network certain messages must occasionally be given absolute priority to the line, even at the cost of interrupting a message already in the process of transmission.)

In our example, when a cross office unit has made a decision to interrupt a message, a common piece of equipment known as a "cancel-transmission transmitter" is temporarily connected to the line and transmits a cancellation sequence followed by an end-of-message indicator. Following this sequence a signal is sent to the cross office unit which had control of the line. This signal disconnects the cross office unit's control of the line, places it in a locked-out condition and causes an alarm condition to be indicated. A supervisor must rethread the tape in the transmitter before permitting it to proceed. (This condition occurs very infrequently, however.) When the original cross office unit has been locked out, the line is immedi-

ately returned to an idle condition, thus permitting the new cross office unit (containing the high-precedence message) to gain control of the line.

At the time that a line becomes idle there could be several cross office units waiting to seize it. In this situation all such cross office units first indicate precedence to the line. Electrical interlocks insure that only a unit containing a message of the highest degree of precedence indicated will seize the line. Thus it can be seen that in a situation involving several cross office units, all waiting for the same line, message traffic can accumulate in the tape storage bins of these units to the capacity of the bins, each of which exceeds twenty average length messages. It can also be seen that the number of cross office units set to a particular line is a function of the amount of traffic to that line. Since in a military network traffic volume to or from a particular station fluctuates widely, the pooled cross office units provide a completely flexible storage medium.

In a teletypewriter network it is often necessary to repeat transmission. It is necessary, therefore, to keep a record of all transmission to each outgoing line. For this purpose a monitor unit is used.

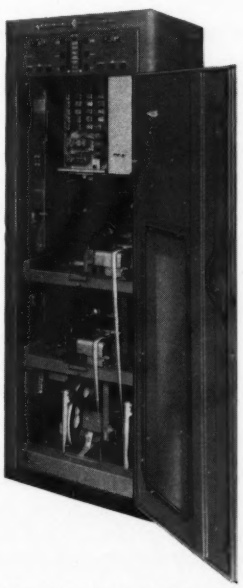

Figure 6. Incoming Line Unit.

It consists of a typing reperforator which produces a record of transmission in punched-tape form. These tapes are automatically taken up on reels and stored for a period of time, for record purposes.

If a Director fails to detect a bona fide routing indicator, receives a supervisory message for the local switching center, or for any reason cannot immediately direct a message to a cross office unit, the message will be directed to a cross office intercept position where the message is reproduced on a tape in such a manner that the tape can be easily torn between messages. This permits an operator to examine each message for appropriate action. If the message requires forwarding, the operator has the facilities of the intercept manual forwarding unit by which the message can be reinserted into the network. Thus it can be seen that every message is immediately cleared from the incoming position to some form of cross office position. In a military network this is highly important, since the incoming line equipment must be left free to act upon a high-precedence message. This is one of the fundamental departures from commercial techniques.

Equipment Description

The Incoming Line Unit

The incoming line unit, shown in Figure 6, consists of a cabinet that houses all teletypewriter and switching equipment which is individual to two incoming lines. The teletypewriter equipment for each line consists of a typing reperforator equipped with tape supply reel, a tape reader, a tape transmitter, and a tape take-up reel on which the spent tape is accumulated. The channel-number comparators and other controls are located on the front panel. Inside are the two associated relay groups (in this system the relay control groups are mounted with the operational equipment to facilitate maintenance and cabling of the center). The tape reader indicates each character to the relay group via five coding wires which are grounded, one or more at a time, depending upon the character read. In the relay group, five sensing relays are used to decode the character. (This application is an excellent example of the use of multi-contact relays, since the decoding process requires indication of several characters, each of

which requires two sets of contacts on each of the five relays.)

With the receipt of the first character of the start-of-message indicator, a set of two relays is operated, preparing the paths for operation of the second set of relays if the next character received is the actual second character of the start-of-message indicator. If the second character received is not the proper one, the first set of relays must immediately release so that it will be ready to operate on the receipt of the next "first character" received. In this manner a sequence of several characters can be used and detected as a start-of-message indicator. Relays were chosen for this application, instead of a stepping switch, because a relay counting chain is capable of being instantly reset to the starting position if a character is received out of sequence.

One of the interesting features of the incoming line unit is the channel-number comparator. It will be recalled that each transmission between two points carries a serial number and that the sequence of these numbers must be checked to guard against lost messages. This is accomplished by keeping in storage the serial number of the next message to be received, and comparing the stored number with the number on the incoming message. The stored number is registered on a set of three 10-point rotary switches of the type shown in Figure 7. Each of these rotary switches is equipped with a large indicator wheel for displaying the contact number to which the switch is set. By mounting these three switches side by side behind a panel, with only one number of each switch showing through a hole in the panel, a three-digit number can be indicated visually. This number is at all times the serial number of the next message to be received; the number is automatically advanced one unit as each message is processed. The visual indication is observed by the supervisor in case of an alarm condition resulting from an improper sequence of messages.

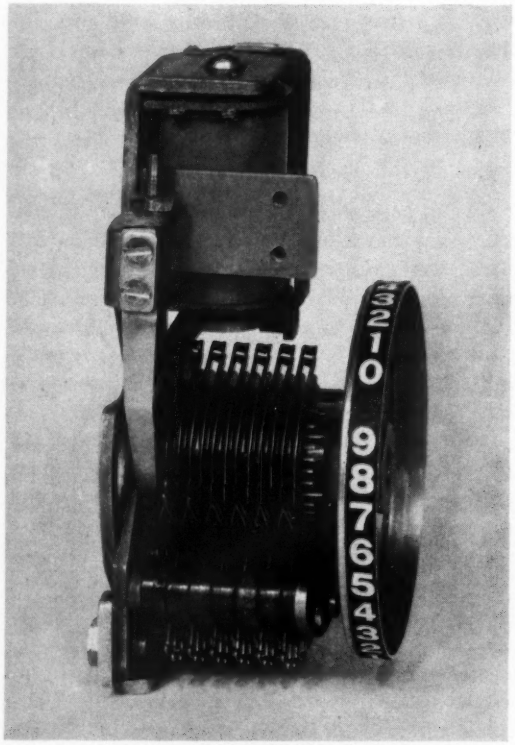

Figure 7. Channel Number Comparator Switch Showing Use of the Large Indicator Wheel.

The banks of the rotary switches are used for automatic checking of the serial number. The actual comparison is accomplished by decoding the first character of the serial number and grounding one of ten leads. These ten leads are connected to bank contacts of the first switch. If this switch is set to the contact connected to the grounded lead, a successful comparison is made and another character is read from the message tape. A Type 44 rotary switch is used to switch control to the second and third rotary switches for checking the succeeding numbers.

The Director

Broadly stated, the function of the Director is that of directing the establishment of transmission paths through the center. This major objective is accomplished by proper control of the following functions:

A. Incoming line selection

B. Precedence detection and storage

C. Routing-indicator detection and storage

D. Control of translation and line-identification storage

E. Selection of a suitable cross office unit

F. Setting of all necessary switches

G. Release

The Director unit is shown in Figure 4. It consists of two Directors, one on each side of the cabinet. In the lower right-hand corner the line selector switch base is visible. This base is common to the two Directors, and consists primarily of two rotary switches per Director mounted adjacent to each other and on the same base to facilitate wiring. The function of these switches is that of finding an incoming line position which has a message to be switched. Since these switches are 25-point switches, each set of two Directors operates with 25 incoming line sets. Under normal traffic loads one of the two Directors can adequately handle all traffic supplied by a group of 25 lines. This is a prime example of the savings realized by use of common Director equipment.

The precedence-sensing relay group is primarily a sensing means to supply the registers of the precedence detector. The output of the tape reader in the incoming line unit is connected to the five sensing relays here, which decode the characters received that constitute precedence indicators, and pass them on to the detector registers of the precedence-detector relay base. In these relay registers, sets of 2-step relays are used (as in the start-of-message detector in the incoming line unit) to pick a particular sequence out of a group of characters. Here, as before, relays are used so as to permit an immediate reset in case a character is received out of sequence.

The address-detector relay group is primarily a set of sensing relays similar to those of the precedence-sensing relay group, but in this case the contacts of the relays are wired to decode only certain letters of the alphabet which are used as first or second characters of the routing indicators. The output of this unit is fed to the routing-register relay base, which is a means of storing temporarily a three-, four-, or five-letter routing indicator in code form. The operation of the routing-register relay base is of particular interest. It consists of five sets of five storage relays each, and five control relays arranged in a counting chain for control of the registers. In the routing-indicator assignment plan the first and second characters can each be one of only a selected few letters, and each of the remaining characters can be any one of the letters of the alphabet. Thus the receipt of two characters which are bona fide letters for their respective positions will establish the basis for a routing indicator sequence. These three, four, or five characters are then stored in the storage registers in sequence.

One of the interesting features of this piece of equipment is its ability to pick a routing indicator out of a group of indiscriminate characters. The receipt of a usable first character causes that character to be stored in the first relay register. The receipt of a usable second character is stored in the second set of registers, thus preparing the third and subsequent registers to receive the remaining characters. If, however, a usable first character is received which is not followed immediately by a usable second character, the first and second registers must be immediately released between characters to be capable of receiving a new first character should one appear. A further aspect of this situation appears when a usable first character is followed by a character which is not usable as a second character but happens to be usable in the first position as the start of a new sequence. In this case the first register must be released and the second character must be stored as a first character. The use of multi-contact relays here facilitates the rapid switching required to store the coded characters in the proper registers.

The Routing Translator Unit

One of the most basic functions of the switching equipment is to determine which outgoing line to select for a particular message. This function is accomplished in approximately 50 milliseconds by the routing translator, which is common to all Directors in any switching center consisting of one hundred lines or less. The translation processes are accomplished by means of Type 57A multi-contact relays and by patching cords with pin-jack connections. (In a commercial system, network changes are relatively infrequent; in a military network, however, overnight changes can and do occur very frequently. It is also possible that military routing indicator assignments may change completely overnight. These factors have dictated the use of pin-jack patching cords in the translation process to permit rapid changes of the switching plan. The translator is also supplied in dupli-

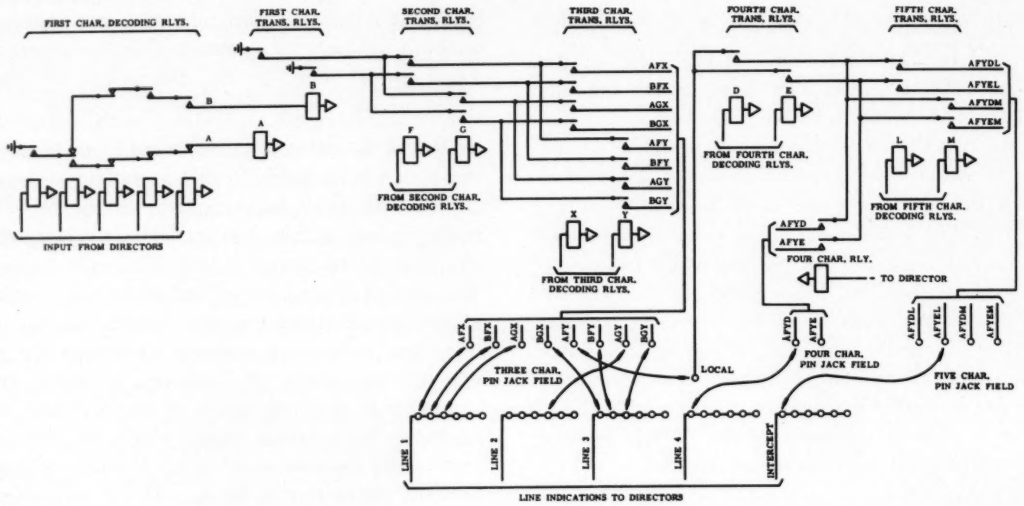

Figure 8. Schematic Diagram Showing Routing Translator Principles.

cate, which permits operation on one switching plan with immediate transfer to another plan when required.)

The basic translator circuitry has been diagrammed in Figure 8. Information is supplied from the Director, via the five sets of five leads each, to operate the five sets of decoding relays. Each of these sets of decoding relays decodes an encoded letter and indicates the letter by operation of one of its associated translation relays. It will be recalled that the first three letters of a routing indicator identify a particular relay center in the network. The operation of one of several possible first-position translation relays extends a ground to contacts, in multiple, of all second-position relays. The operation of one of the second-position relays likewise extends one grounded lead to contacts of all third-position relays. The operation of one of the third-position relays extends the ground to a pin-jack which identifies a particular relay center. Likewise all possible combinations of the first three characters are connected to similar pin-jacks.

The arrangement of switching centers and tributary stations is such that no switching center need ever transmit a message directly to a tributary station of another switching center; thus the receipt of a routing indicator which has the first three letters identifying a center other than the local switching center indicates that no action is required on the fourth or fifth character. Only the pin-jack in the three-letter field which represents the local switching center is strapped to the "local" pin-jack, which starts another translation ground through the fourth- and fifth-character translation relays, ultimately to re-appear at the fourth- or fifth-character pin-jack fields. Single-conductor patching cords are used to connect the assigned routing indicators of the network to the desired outgoing line.

The Multiple Call System

Before we consider the equipment required to process multiple-address messages we should have some understanding of the multiple-address procedure as used in the Signal Corps. Military networks use two types of multiple-address procedure. One of these requires that personnel at each relay center must know by pre-arrangement the correct routing for each routing indicator under a particular set of circumstances, and must route all messages accordingly. This type of routing is used to best advantage when the network is constructed

along command lines or is so arranged that the bulk of message traffic is from or to a centralized switching center with little or no traffic passing between adjacent switching centers. The other type of multiple-message processing requires that personnel at the originating station assign a definite responsibility to a particular relay center. This method is used by the Signal Corps primarily because it avoids the confusion of considering message origin in networks which make extensive use of interconnecting trunks between many switching centers of the network.

As an example of this type of message we can assume a message originating at station AA, which is a tributary station of switching center A. An operator at station AA addresses a message to stations CA and CB, and instructs relay center C that it is to be responsible for multiple transmission. The message may travel as single transmissions through relay centers A and B because only relay center C has been designated as the one to make a multiple transmission. This method requires knowledge of the network by the originating operator and by switching center operators, but it has the advantage of fixing definite responsibility for transmission of the message. Quite frequently a switching center will receive a multiple-address message, and in segregating the routing indicators for retransmission the operator finds that two or more routing indicators can be reached via another switching center. In this case a "pilot" is attached, preceding the heading of the message, assigning further multiple address responsibility for the routing indicators concerned. In all cases a "pilot" preceding a message is followed immediately by another pilot or by the original message heading.

Sequence of Operations

When a Director detects the special sequence indicating local responsibility for a multiple-address message, the message is routed immediately to a multiple-call storage unit. This unit is similar in appearance to the cross office unit, and serves to collect multiple-address messages prior to processing. As in the case of the cross office unit the tape is read immediately by a tape reader, which transfers coded characters to the associated relay control group. When a start-of-message indicator is sensed, the tape reader is stopped until the processing equipment is available. The processing equipment is common to several storage units, and is assigned to each for the duration of one message.

When the processing equipment has been connected to the storage unit the tape reader is permitted to continue, and information passes from the tape reader to the processing equipment. The precedence of the message is recorded in the processing equipment, following which the first routing indicator is detected and stored. The receipt of the first routing indicator causes the tape reader to stop, and to start a group of operations. The first of these operations is a translation, and for this purpose the routing translator is used. The second operation is the placing in storage of the associated routing indicator. Perforated paper tape was chosen for these storage mediums because it permits use of up to one hundred routing indicators in any one message. The remaining operation is the seizure of the cross office unit, which will be held for transmission at a later time; a cross office unit is selected for this purpose in exactly the same manner as in the case of single-address messages.

Following the completion of these operations, the second and all subsequent routing indicators are read and processed similarly. Thus a new cross office unit is seized each time a different outgoing line is indicated. Part of the processing involves keeping in relay storage the three letters identifying the relay center which is to be responsible for multiple processing of any of the outgoing transmissions. Thus when a particular outgoing line is indicated by the routing translator for a second or subsequent time a comparison of the new routing indicator and the one previously in storage must be made. As a result of this comparison a new routing indicator might be placed in storage in place of the one previously held. Thus for each indicated outgoing line to be used, the three-letter switching center routing indicator is held in storage for use at a later time.

After the last routing indicator has been processed, transmission to the cross office units is started. The first item of information is transmitted simultaneously to all seized cross office units. It consists of the start-of-message indicator and the precedence indicator. Following this, individual pilots are transmitted to each cross office unit as

required. These pilots consist of individual handling instructions assigning specific transmission responsibility where required. For this purpose the 3-letter switching center designations mentioned above become part of the respective pilots. Then the routing indicators, which were previously placed in tape storage, are withdrawn from storage and transmitted to the cross office units indicated by the line numbers which were also placed in storage. In this manner a specific pilot, including applicable routing indicators, is transmitted to each cross office unit. Following completion of all these pilot messages, the original address portion and the body of the message are transmitted from the multiple call storage unit, in multiple to all seized cross office units. After completion of the message the processing equipment and the cross office units are released.

The multiple address processing equipment is largely a collection of relays and rotary switches which are connected together to control a logical sequence of events. This equipment can be grouped into the following general classifications:

a) Sensing relays
b) Storage relays and switches
c) Transmission control switches
d) Sequence control relays and switches.

The sensing relays are a means of transferring information from tape form to relay storage. The storage relays and switches are of many different forms, but they all constitute a means of putting a piece of information away until it is needed. The transmission control switches encode information taken from storage, to permit its transmission as required. The sequence control relays control all of the functions of sensing, storage, and transmission.

The sensing relays have been previously described. The encoding equipment, however, consisting of the transmission control switches, is equally important to the functioning of the multiple call system, because one of the functions of the system is the creation of specific pilot messages which must be transmitted as a sequence of teletypewriter characters. The basic principles of encoding are illustrated by the schematic diagrams of Figure 9. The upper diagram shows a schematic representation of a typical teletypewriter transmitter. It consists of a set of six transmitting contacts which are wired as shown. When nothing is being transmitted, a ground is maintained on the signal lead via the normally closed contacts. As a mechanical cycle starts, these contacts open for a definite period, following which the remaining five contacts close or remain open in timed sequence, depending upon the character to be transmitted. The action of the contacts is controlled by the positions of the sensing pins, which in turn are controlled by the presence or absence of holes in the tape.

The multiple call system requires in many instances that information be withdrawn from relay or rotary switch storage and transmitted directly to the signal circuit. To accomplish this function a standard transmitter was modified by splitting apart the common electrical connection on one side and wiring it to a control switch as shown in the lower diagram. By operating the transmitter without tape all sensing pins are permitted to operate, thus causing all contacts to close in sequence. External control of the grounds to the respective contacts has the same effect as closing or opening the contacts through operation of the sensing pins

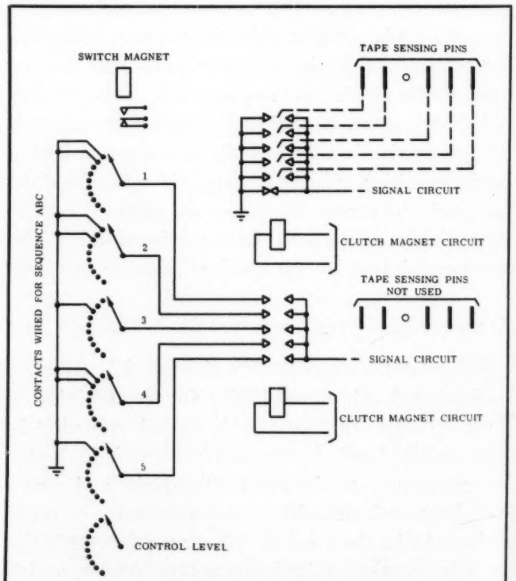

Figure 9. Schematic Diagram Showing the Markable Transmitter Principles.

Figure 10. View of typical bay of switching equipment showing methods of mounting equipment.

in a normal transmitter. In operation a pulse is sent to the rotary switch, which steps from its normal position to its first position. Immediately following this a pulse is applied to the clutch magnet of the transmitter, thus causing transmission of the character which is represented by the ground pattern on the first five levels of the switch. Subsequently, succeeding pulses are applied to the switch and the transmitter, thus causing a multi-letter sequence to be transmitted. It should be noted that, while the control switch as shown has its bank contacts grounded directly to transmit a fixed sequence, these contacts are often connected to other supplementary switches, thus permitting transmission of a variable sequence. This plan of controlling a teletypewriter transmitter is the heart of the multiple call processing operation.

The method of mounting the equipment is shown in Figure 10. Each cabinet has an angle-iron frame to which the relay equipment is mounted. Wherever possible, the relays are mounted on bases that are electrically jack-connected to the frame (as many as 144 electrical connections are made by these jack connections on a single base). To make insertion and removal of the bases easy, the bases are hung on two pins at the upper end and are then swung into position at the lower end. In each cabinet all wiring is terminated on terminal blocks; installation consists of terminating cables on these terminal blocks. All relay equipment is provided with dust covers and is doubly protected by doors on the cabinets.

Conclusion

This experimental installation at Fifth Army Headquarters, Chicago, has been regarded as a first step towards the goal of a completely automatic network. Several larger switching centers are being planned which will incorporate many new features and techniques, as well as a completely new line of teletypewriter equipment which is being adapted especially for use with automatic switching techniques. Much effort is being exerted to streamline network procedure and message for-

mat. It is expected that these efforts and the more extensive use of automatic switching equipment such as this will result in smoother, more efficient operation in meeting the ever-increasing demand for more and better communications.

Acknowledgements

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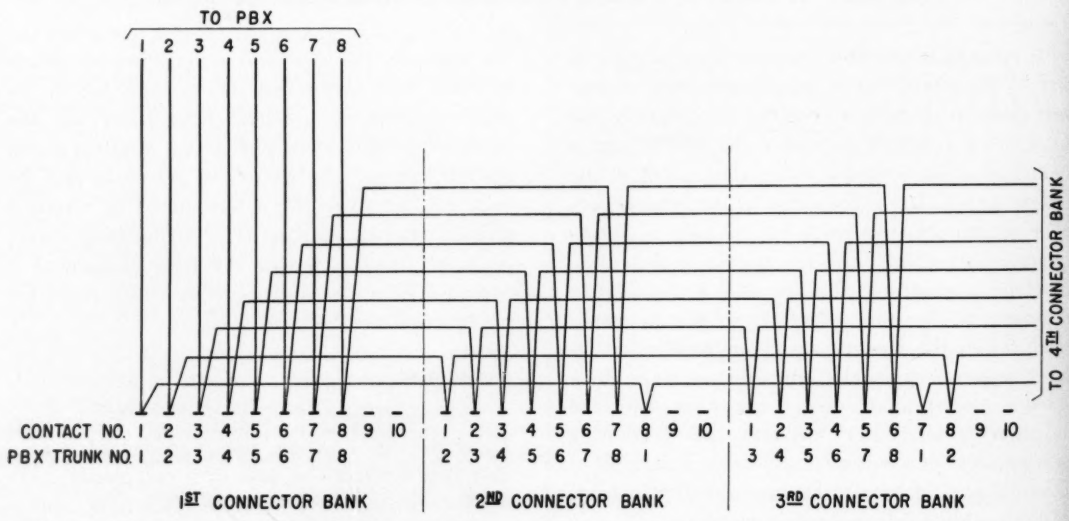
EMERGENCY P-B-X ROTARY TRUNK SERVICE

When the traffic people of one operating company assigned an important P-B-X to a number in a regular connector group instead of in a rotary connector group, they created a problem for the installers who were at that very time preparing to cut over to Strowger operation.

As the new directory had been printed and distributed, and this number had also been publicized by other means, a new number could not be assigned unless the *incorrectly* assigned number was placed on intercept. Furthermore, as only the first number in the group of eight P-B-X trunks had been published, all calls would come in on that one trunk if no rotary trunk service were provided; this would, of course, result in an excessive number of busy signals and angry subscribers. The new directory was effective at midnight of the evening the error was discovered; therefore, something had to be done quickly.

The flexibility of the Strowger-type bank multiple provided a simple solution to this pressing problem. The method adopted was simply to "slip" the connector bank multiple so that the rotary action at the preceding selectors was utilized to distribute the traffic over the eight P-B-X trunks. This rearrangement of the connector bank wiring is shown in the illustration.

G. O. Tapper, *Chicago*


TO PBX
1 2 3 4 5 6 7 8
TO 4TH CONNECTOR BANK
CONTACT NO. 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10 | 1 2 3 4 5 6 7 8 9 10
PBX TRUNK NO. 1 2 3 4 5 6 7 8 | 2 3 4 5 6 7 8 1 | 3 4 5 6 7 8 1 2
1ST CONNECTOR BANK
2ND CONNECTOR BANK
3RD CONNECTOR BANK